# APPENDIX B

## Population Data, Normalized Growth Factors, and Normalized Total Production Indices

SECTION 3 - ASSESSING AIR POLLUTANT EMISSIONS

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(continued)

SECTION 3 - ASSESSING AIR POLLUTANT EMISSIONS

List of Tables

Appendix B

(continued)

TABLE B.3.. From Dept. of Finance Report 75 E-2, October 28, 1975

TABLE 2. TOTAL POPULATION OF CALIFORNIA COUNTIES, JULY 1, 1970 TO JULY 1, 1975

| County | July 1, 1970 | July 1, 1971 | July 1, 1972 | July 1, 1973 | July 1, 1974 | July 1, 1975 |
|---|---|---|---|---|---|---|
| Alameda | 1,072,700 | 1,088,100 | 1,094,400 | 1,089,100 | 1,087,300 | 1,086,600 |
| Alpine[1] | 500 | 500 | 600 | 700 | 800 | 800 |
| Amador[1] | 11,900 | 12,800 | 12,800 | 13,800 | 14,700 | 15,100 |
| Butte | 102,500 | 104,500 | 108,900 | 111,700 | 114,100 | 116,900 |
| Calaveras | 13,700 | 13,900 | 14,400 | 14,900 | 15,500 | 16,100 |
| Colusa | 12,400 | 12,400 | 12,300 | 12,400 | 12,600 | 12,800 |
| Contra Costa[1] | 557,400 | 562,900 | 567,600 | 573,600 | 578,300 | 584,900 |
| Del Norte | 14,600 | 15,000 | 15,100 | 15,200 | 15,300 | 15,600 |
| El Dorado[1] | 44,100 | 46,400 | 49,700 | 52,500 | 55,700 | 59,200 |
| Fresno[1] | 413,800 | 422,100 | 427,900 | 432,100 | 439,500 | 447,100 |
| Glenn | 17,500 | 17,600 | 17,900 | 18,300 | 18,600 | 18,900 |
| Humboldt | 100,100 | 100,900 | 102,200 | 103,800 | 104,900 | 104,400 |
| Imperial[1] | 74,500 | 76,300 | 77,100 | 79,600 | 82,100 | 84,100 |
| Inyo[1] | 15,600 | 16,300 | 16,400 | 16,800 | 16,600 | 16,900 |
| Kern | 330,700 | 335,500 | 336,300 | 337,300 | 337,900 | 342,800 |
| Kings[1] | 66,700 | 67,000 | 68,400 | 69,200 | 68,000 | 68,200 |
| Lake | 19,800 | 21,000 | 22,300 | 23,300 | 24,200 | 25,500 |
| Lassen | 16,900 | 17,000 | 17,500 | 17,500 | 17,700 | 18,700 |
| Los Angeles | 7,047,100 | 7,071,200 | 6,988,900 | 6,966,200 | 6,955,500 | 6,970,000 |
| Madera | 41,600 | 42,600 | 43,200 | 43,700 | 45,100 | 46,200 |
| Marin | 207,000 | 209,200 | 211,500 | 214,100 | 211,500 | 213,800 |
| Mariposa | 6,100 | 6,500 | 6,900 | 7,500 | 7,900 | 8,200 |
| Medocino | 51,300 | 52,300 | 52,900 | 55,300 | 56,900 | 57,600 |
| Merced | 105,000 | 107,900 | 111,500 | 111,700 | 115,100 | 117,000 |
| Modoc | 7,500 | 7,700 | 7,900 | 7,900 | 8,200 | 8,100 |
| Mono[1] | 4,100 | 4,800 | 5,800 | 6,600 | 6,800 | 7,300 |
| Monterey | 247,700 | 255,000 | 253,300 | 255,400 | 261,600 | 266,400 |
| Napa | 79,400 | 80,500 | 82,800 | 84,400 | 86,900 | 88,600 |
| Nevada[1] | 26,500 | 27,100 | 28,700 | 30,400 | 31,900 | 33,900 |
| Orange | 1,431,600 | 1,471,000 | 1,526,700 | 1,592,300 | 1,653,500 | 1,694,900 |
| Placer[1] | 78,000 | 79,400 | 81,400 | 84,800 | 87,900 | 90,000 |
| Plumas | 11,700 | 12,000 | 12,500 | 13,200 | 13,600 | 14,000 |
| Riverside | 461,400 | 474,000 | 488,500 | 501,600 | 514,200 | 526,600 |
| Sacramento[1] | 636,600 | 645,700 | 661,000 | 670,300 | 682,600 | 687,400 |
| San Benito | 18,300 | 18,500 | 18,700 | 18,900 | 19,200 | 19,700 |
| San Bernardino[1] | 685,200 | 689,500 | 690,500 | 691,400 | 694,600 | 698,300 |
| San Diego[1] | 1,366,900 | 1,388,400 | 1,419,800 | 1,472,200 | 1,527,700 | 1,571,700[2] |
| San Francisco | 712,100 | 709,000 | 695,800 | 692,800 | 679,200 | 667,700 |
| San Joaquin | 292,000 | 293,600 | 296,500 | 296,800 | 298,500 | 302,000 |
| San Luis Obispo | 106,400 | 108,500 | 112,300 | 117,200 | 122,000 | 127,800 |
| San Mateo | 557,200 | 559,900 | 560,900 | 565,500 | 568,900 | 571,100 |
| Santa Barbara | 265,700 | 268,700 | 272,400 | 275,000 | 279,200 | 281,300 |
| Santa Clara | 1,072,400 | 1,093,600 | 1,122,000 | 1,146,900 | 1,169,400 | 1,190,000 |
| Santa Cruz | 124,500 | 128,600 | 137,300 | 141,200 | 145,000 | 148,400 |
| Shasta | 78,000 | 79,200 | 80,600 | 83,900 | 86,200 | 87,700 |
| Sierra | 2,400 | 2,400 | 2,500 | 2,500 | 2,500 | 2,600 |
| Siskiyou | 33,200 | 33,500 | 34,000 | 34,600 | 34,800 | 34,900 |
| Solano | 172,400 | 178,100 | 180,900 | 179,700 | 181,200 | 184,000 |
| Sonoma | 206,400 | 210,900 | 221,400 | 231,400 | 238,800 | 242,800 |
| Stanislaus | 195,700 | 198,900 | 199,800 | 204,600 | 207,800 | 212,400 |
| Sutter[1] | 42,100 | 42,800 | 43,200 | 44,300 | 45,200 | 46,000 |
| Tehama | 29,600 | 29,900 | 30,100 | 30,700 | 31,600 | 31,800 |
| Trinity | 7,600 | 8,000 | 8,500 | 8,900 | 9,300 | 9,600 |
| Tulare | 189,100 | 194,000 | 196,700 | 199,600 | 202,600 | 207,700 |
| Tuolumne[1] | 22,300 | 23,000 | 23,700 | 24,800 | 25,400 | 26,000 |
| Ventura[1] | 381,400 | 389,800 | 404,200 | 415,200 | 427,000 | 438,200 |
| Yolo[1] | 92,700 | 93,400 | 96,300 | 97,200 | 98,600 | 101,700 |
| Yuba[1] | 44,400 | 45,700 | 45,600 | 44,500 | 44,300 | 45,000 |
| California | 20,026,000 | 20,265,000 | 20,419,000 | 20,647,000 | 20,882,000 | 21,113,000[2] |

[1] Estimates have been adjusted to reflect the results of a special census.

[2] Numbers do not include 17,777 refugees living at Camp Pendleton, San Diego County, on July 1, 1975. This temporary population is expected to be relocated by the end of the year.

TABLE B.3.2

TOTAL POPULATION OF CALIFORNIA COUNTIES, PROJECTED 1980-1995
Series D-100

| County | 1980 Series D-100 | 1985 Series D-100 | 1990 Series D-100 | 1995 Series D-100 |
|---|---|---|---|---|
| Alameda- - - - - - | 1,143,800 | 1,194,800 | 1,251,200 | 1,305,500 |
| Alpine - - - - - - | 700 | 800 | 900 | 1,200 |
| Amador - - - - - - | 18,100 | 20,400 | 22,400 | 24,000 |
| Butte- - - - - - - | 129,400 | 143,000 | 156,800 | 170,000 |
| Calaveras- - - - - | 18,800 | 21,100 | 23,100 | 24,700 |
| Colusa - - - - - - | 12,500 | 12,900 | 13,500 | 14,300 |
| Contra Costa - - - | 652,800 | 715,200 | 780,900 | 844,700 |
| Del Norte- - - - - | 16,400 | 17,700 | 19,100 | 20,600 |
| El Dorado- - - - - | 64,200 | 76,100 | 87,700 | 96,100 |
| Fresno - - - - - - | 477,200 | 513,500 | 550,900 | 586,400 |
| Glenn- - - - - - - | 19,100 | 20,300 | 21,300 | 22,000 |
| Humboldt - - - - - | 108,300 | 114,400 | 121,100 | 127,600 |
| Imperial - - - - - | 86,300 | 94,100 | 101,800 | 108,800 |
| Inyo - - - - - - - | 19,900 | 22,400 | 24,700 | 26,700 |
| Kern - - - - - - - | 365,200 | 386,000 | 406,300 | 424,400 |
| Kings- - - - - - - | 69,500 | 74,400 | 80,000 | 85,300 |
| Lake - - - - - - - | 28,200 | 31,600 | 34,100 | 36,500 |
| Lassen - - - - - - | 20,300 | 22,000 | 23,200 | 24,100 |
| Los Angeles- - - - | 6,963,200 | 7,122,900 | 7,346,800 | 7,591,600 |
| Madera - - - - - - | 49,600 | 54,000 | 58,400 | 62,300 |
| Marin- - - - - - - | 233,200 | 249,200 | 265,400 | 280,200 |
| Mariposa - - - - - | 9,300 | 10,700 | 12,000 | 13,200 |
| Mendocino- - - - - | 65,100 | 73,000 | 79,500 | 85,500 |
| Merced - - - - - - | 126,300 | 138,900 | 151,400 | 162,500 |
| Modoc- - - - - - - | 8,100 | 8,400 | 8,700 | 9,000 |
| Mono - - - - - - - | 10,500 | 13,100 | 14,900 | 16,600 |
| Monterey - - - - - | 299,000 | 329,800 | 362,100 | 396,500 |
| Napa - - - - - - - | 101,600 | 113,800 | 126,600 | 139,200 |
| Nevada - - - - - - | 37,200 | 42,100 | 46,700 | 51,000 |
| Orange - - - - - - | 1,970,500 | 2,233,900 | 2,465,300 | 2,647,500 |
| Placer - - - - - - | 109,500 | 125,000 | 137,600 | 148,900 |
| Plumas - - - - - - | 15,400 | 17,100 | 18,400 | 19,600 |
| Riverside- - - - - | 596,900 | 676,700 | 755,500 | 825,800 |
| Sacramento - - - - | 753,600 | 820,400 | 884,900 | 944,200 |
| San Benito - - - - | 21,000 | 23,000 | 25,100 | 27,100 |
| San Bernardino - - | 765,100 | 836,400 | 913,800 | 995,100 |
| San Diego- - - - - | 1,801,300 | 2,022,400 | 2,242,300 | 2,449,500 |
| San Francisco- - - | 661,100 | 653,500 | 653,700 | 655,100 |
| San Joaquin- - - - | 330,200 | 352,500 | 375,000 | 396,600 |
| San Luis Obispo- - | 147,500 | 164,300 | 181,000 | 197,300 |
| San Mateo- - - - - | 593,100 | 616,300 | 637,500 | 653,800 |
| Santa Barbara- - - | 305,800 | 333,700 | 361,900 | 388,300 |
| Santa Clara- - - - | 1,342,800 | 1,487,800 | 1,614,300 | 1,721,700 |
| Santa Cruz - - - - | 177,200 | 203,400 | 227,800 | 252,200 |
| Shasta - - - - - - | 98,200 | 108,100 | 117,400 | 125,500 |
| Sierra - - - - - - | 2,700 | 2,800 | 3,000 | 3,200 |
| Siskiyou - - - - - | 38,200 | 41,100 | 43,300 | 45,000 |
| Solano - - - - - - | 198,400 | 220,800 | 249,400 | 283,600 |
| Sonoma - - - - - - | 300,500 | 349,300 | 395,400 | 438,700 |
| Stanislaus - - - - | 235,400 | 256,700 | 278,300 | 296,500 |
| Sutter - - - - - - | 49,900 | 54,700 | 59,500 | 63,700 |
| Tehama - - - - - - | 34,500 | 37,100 | 39,400 | 41,000 |
| Trinity- - - - - - | 10,500 | 11,900 | 12,900 | 13,400 |
| Tulare - - - - - - | 224,300 | 245,500 | 267,300 | 288,400 |
| Tuolumne - - - - - | 32,200 | 36,100 | 39,500 | 42,200 |
| Ventura- - - - - - | 523,300 | 612,100 | 704,400 | 791,000 |
| Yolo - - - - - - - | 118,800 | 133,000 | 147,300 | 161,100 |
| Yuba - - - - - - - | 47,300 | 50,800 | 55,300 | 59,500 |
| The State- - - - - | 22,659,000 | 24,363,000 | 26,098,000 | 27,726,000 |

From California Department of Finance Report 74 P-2, June 1974

TABLE B.3.3

TOTAL POPULATION OF CALIFORNIA COUNTIES, PROJECTED 1980-1995

SERIES E-0

| County | 1980<br>Series E-0 | 1985<br>Series E-0 | 1990<br>Series E-0 | 1995<br>Series E-0 |
|---|---|---|---|---|
| Alameda | 1,121,500 | 1,148,100 | 1,171,700 | 1,188,000 |
| Alpine | 600 | 600 | 600 | 600 |
| Amador | 17,200 | 18,100 | 18,600 | 18,900 |
| Butte | 124,900 | 131,100 | 136,700 | 141,500 |
| Calaveras | 18,000 | 18,700 | 19,200 | 19,500 |
| Colusa | 12,300 | 12,400 | 12,600 | 12,700 |
| Contra Costa | 639,400 | 681,400 | 721,600 | 756,600 |
| Del Norte | 15,900 | 16,700 | 17,400 | 17,800 |
| El Dorado | 60,800 | 66,300 | 70,800 | 74,600 |
| Fresno | 466,800 | 491,600 | 515,900 | 537,600 |
| Glenn | 18,700 | 19,200 | 19,400 | 19,400 |
| Humboldt | 105,700 | 109,100 | 112,400 | 115,100 |
| Imperial | 84,400 | 90,000 | 95,500 | 100,100 |
| Inyo | 19,400 | 20,900 | 21,900 | 22,500 |
| Kern | 357,900 | 372,600 | 385,500 | 394,600 |
| Kings | 67,700 | 70,500 | 73,200 | 75,600 |
| Lake | 27,000 | 28,400 | 29,100 | 29,700 |
| Lassen | 19,800 | 20,500 | 20,700 | 20,700 |
| Los Angeles | 6,674,500 | 6,574,700 | 6,571,100 | 6,569,100 |
| Madera | 47,800 | 50,400 | 52,600 | 54,400 |
| Marin | 228,900 | 239,100 | 248,600 | 256,600 |
| Mariposa | 8,900 | 9,100 | 8,900 | 8,500 |
| Mendocino | 62,900 | 66,600 | 69,000 | 70,800 |
| Merced | 123,000 | 130,900 | 137,900 | 143,800 |
| Modoc | 8,000 | 8,100 | 8,100 | 8,100 |
| Mono | 9,700 | 10,500 | 10,600 | 10,600 |
| Monterey | 290,900 | 309,400 | 328,600 | 346,900 |
| Napa | 98,300 | 103,300 | 107,500 | 111,200 |
| Nevada | 35,700 | 36,700 | 35,900 | 34,900 |
| Orange | 1,900,500 | 2,063,600 | 2,194,900 | 2,299,500 |
| Placer | 104,400 | 110,300 | 115,100 | 118,700 |
| Plumas | 14,900 | 15,600 | 15,700 | 15,600 |
| Riverside | 580,200 | 632,100 | 681,300 | 725,500 |
| Sacramento | 736,000 | 777,500 | 816,600 | 849,900 |
| San Benito | 20,500 | 21,600 | 22,600 | 23,600 |
| San Bernardino | 741,400 | 783,900 | 825,900 | 862,800 |
| San Diego | 1,750,600 | 1,905,800 | 2,044,400 | 2,159,500 |
| San Francisco | 651,400 | 635,700 | 621,900 | 610,000 |
| San Joaquin | 322,000 | 335,700 | 348,300 | 359,500 |
| San Luis Obispo | 141,300 | 149,900 | 156,600 | 162,800 |
| San Mateo | 583,700 | 597,900 | 609,400 | 615,900 |
| Santa Barbara | 298,900 | 313,600 | 326,500 | 337,400 |
| Santa Clara | 1,309,200 | 1,399,200 | 1,482,400 | 1,547,200 |
| Santa Cruz | 170,500 | 181,000 | 187,200 | 193,000 |
| Shasta | 95,000 | 100,000 | 103,500 | 105,800 |
| Sierra | 2,600 | 2,600 | 2,600 | 2,600 |
| Siskiyou | 37,300 | 38,800 | 39,500 | 39,900 |
| Solano | 192,900 | 205,900 | 219,200 | 232,000 |
| Sonoma | 287,200 | 313,600 | 335,000 | 355,200 |
| Stanislaus | 226,400 | 237,700 | 248,100 | 257,100 |
| Sutter | 48,200 | 50,600 | 52,300 | 53,600 |
| Tehama | 33,700 | 34,700 | 34,900 | 34,900 |
| Trinity | 10,100 | 10,600 | 10,700 | 10,600 |
| Tulare | 218,600 | 232,400 | 245,600 | 257,400 |
| Tuolumne | 30,400 | 31,700 | 31,600 | 31,300 |
| Ventura | 497,700 | 550,200 | 601,600 | 643,300 |
| Yolo | 114,500 | 121,600 | 128,000 | 133,700 |
| Yuba | 46,300 | 48,200 | 50,000 | 51,300 |
| The State | 21,933,000 | 22,757,000 | 23,573,000 | 24,250,000 |

From California Department of Finance Report 74 P-2, 1974

TABLE B.3.4

EXAMPLE CALCULATION FOR POPULATION GROWTH FACTORS

The procedure for projecting emission from certain source categories requires population growth factors for future years. These growth factors are calculated using the values given for base year populations (Table B.3.1 or other references) and future year population projections. As an example, the population growth factors for Orange County are developed below using a base year of 1973 and Series D-100 population projections.

SERIES D-100 POPULATION GROWTH FACTORS

Orange County

| Year | Future Years | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 |
| Population | 1,592,300[a] | 1,653,500[a] | 1,694,900[a] | 1,970,500[b] | 2,233,900[b] | 2,465,300[b] | 2,647,500[b] |
| Growth Factors | 1.000[c] | 1.038[c] | 1.064[c] | 1.238[c] | 1.402[c] | 1.548[c] | 1.663[c] |

[a] From Table B.3.1

[b] From Table B.3.2

[c] 19XY Growth Factor = (19XY Population/1973 Population)

TABLE B.3.5

FRESNO COUNTY - Fresno SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 99 | 99 | 100 | 100 | 100 | 101 | 101 | 105 | 109 | 118 | 128 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 121 | 114 | 107 | 100 | 94 | 88 | 90 | 92 | 97 | 101 | 105 |
| NONMETALLIC, EXCEPT FUELS | 94 | 96 | 98 | 100 | 102 | 104 | 131 | 149 | 167 | 199 | 238 |
| CONTRACT CONSTRUCTION | 92 | 95 | 97 | 100 | 103 | 105 | 120 | 143 | 171 | 210 | 257 |
| MANUFACTURING | 84 | 89 | 94 | 100 | 106 | 113 | 139 | 170 | 206 | 254 | 313 |
| FOOD & KINDRED PRODUCTS | 86 | 90 | 95 | 100 | 105 | 111 | 131 | 152 | 176 | 205 | 239 |
| TEXTILE MILL PRODUCTS | 95 | 97 | 98 | 100 | 102 | 104 | 126 | 148 | 173 | 205 | 243 |
| APPAREL & OTHER FABRIC PR | 83 | 88 | 94 | 100 | 106 | 113 | 145 | 180 | 223 | 277 | 344 |
| LUMBER PRODUCTS & FURNITU | 83 | 88 | 94 | 100 | 106 | 113 | 136 | 162 | 192 | 229 | 274 |
| PAPER & ALLIED PRODUCTS | 80 | 86 | 93 | 100 | 108 | 116 | 157 | 205 | 267 | 350 | 458 |
| PRINTING & PUBLISHING | 93 | 95 | 97 | 100 | 103 | 105 | 124 | 147 | 175 | 213 | 260 |
| CHEMICALS & ALLIED PRODUC | 70 | 79 | 89 | 100 | 113 | 127 | 181 | 243 | 325 | 438 | 591 |
| PETROLEUM REFINING | 63 | 74 | 86 | 100 | 117 | 136 | 182 | 222 | 276 | 340 | 419 |
| PRIMARY METALS | 86 | 90 | 95 | 100 | 105 | 111 | 130 | 149 | 169 | 193 | 222 |
| FABRICATED METALS & ORDNA | 89 | 92 | 96 | 100 | 104 | 108 | 142 | 184 | 236 | 306 | 395 |
| MACHINERY, EXCLUDING ELEC | 81 | 87 | 93 | 100 | 107 | 116 | 147 | 183 | 228 | 287 | 361 |
| ELECTRICAL MACHINERY & SU | 96 | 97 | 99 | 100 | 101 | 103 | 112 | 148 | 196 | 254 | 329 |
| MOTOR VEHICLES & EQUIPMEN | 71 | 80 | 89 | 100 | 112 | 125 | 172 | 208 | 252 | 309 | 380 |
| TRANS. EQUIP., EXCL. MTR. | 135 | 122 | 110 | 100 | 91 | 82 | 53 | 59 | 65 | 71 | 77 |
| OTHER MANUFACTURING | 90 | 93 | 97 | 100 | 104 | 107 | 132 | 163 | 201 | 249 | 309 |
| POPULATION (SERIES C-150) | 96 | 98 | 99 | 100 | 102 | 103 | 112 | 122 | 133 | 145 | 157 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 96 | 97 | 99 | 100 | 101 | 103 | 110 | 117 | 125 | 132 | 140 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 101 | 101 | 102 | 102 | 103 |
| NONMETALLIC, EXCEPT FUELS | 92 | 94 | 97 | 100 | 103 | 106 | 121 | 137 | 154 | 171 | 190 |
| CONTRACT CONSTRUCTION | 90 | 93 | 96 | 100 | 104 | 107 | 127 | 149 | 173 | 200 | 229 |
| MANUFACTURING | 89 | 93 | 96 | 100 | 104 | 108 | 129 | 152 | 178 | 207 | 239 |
| FOOD & KINDRED PRODUCTS | 93 | 95 | 98 | 100 | 102 | 105 | 117 | 130 | 144 | 158 | 173 |
| TEXTILE MILL PRODUCTS | 88 | 92 | 96 | 100 | 104 | 109 | 132 | 158 | 188 | 222 | 259 |
| APPAREL & OTHER FABRIC PR | 85 | 90 | 95 | 100 | 105 | 111 | 141 | 178 | 220 | 270 | 328 |
| LUMBER PRODUCTS & FURNITU | 88 | 92 | 96 | 100 | 104 | 108 | 131 | 157 | 187 | 219 | 255 |
| PAPER & ALLIED PRODUCTS | 86 | 90 | 95 | 100 | 105 | 110 | 140 | 174 | 214 | 261 | 314 |
| PRINTING & PUBLISHING | 90 | 93 | 97 | 100 | 104 | 107 | 126 | 148 | 171 | 196 | 224 |
| CHEMICALS & ALLIED PRODUC | 87 | 91 | 96 | 100 | 105 | 109 | 135 | 165 | 200 | 239 | 283 |
| PETROLEUM REFINING | 92 | 95 | 97 | 100 | 103 | 105 | 119 | 133 | 149 | 165 | 181 |
| PRIMARY METALS | 94 | 96 | 98 | 100 | 102 | 104 | 114 | 124 | 134 | 144 | 155 |
| FABRICATED METALS & ORDNA | 86 | 90 | 95 | 100 | 105 | 110 | 135 | 174 | 214 | 260 | 314 |
| MACHINERY, EXCLUDING ELEC | 89 | 93 | 96 | 100 | 104 | 107 | 128 | 150 | 175 | 201 | 231 |
| ELECTRICAL MACHINERY & SU | 82 | 88 | 94 | 100 | 107 | 114 | 154 | 205 | 268 | 345 | 439 |
| MOTOR VEHICLES & EQUIPMEN | 87 | 91 | 95 | 100 | 105 | 110 | 136 | 167 | 203 | 243 | 290 |
| TRANS. EQUIP., EXCL. MTR. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| OTHER MANUFACTURING | 87 | 91 | 95 | 100 | 105 | 110 | 136 | 167 | 202 | 243 | 288 |
| POPULATION (SERIES E-0) | 96 | 98 | 99 | 100 | 102 | 103 | 108 | 114 | 119 | 124 | 129 |

## TABLE B.3.6
## KERN COUNTY - Bakersfield SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 95 | 97 | 99 | 100 | 101 | 103 | 110 | 114 | 119 | 129 | 140 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 90 | 93 | 96 | 100 | 104 | 108 | 118 | 128 | 139 | 151 | 164 |
| NONMETALLIC, EXCEPT FUELS | 99 | 99 | 100 | 100 | 100 | 101 | 116 | 134 | 154 | 179 | 209 |
| CONTRACT CONSTRUCTION | 73 | 81 | 90 | 100 | 111 | 123 | 152 | 188 | 231 | 290 | 365 |
| MANUFACTURING | 82 | 88 | 94 | 100 | 107 | 114 | 143 | 173 | 212 | 260 | 320 |
| FOOD & KINDRED PRODUCTS | 93 | 95 | 98 | 100 | 103 | 105 | 125 | 147 | 173 | 204 | 241 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 78 | 85 | 92 | 100 | 109 | 118 | 154 | 196 | 246 | 313 | 399 |
| LUMBER PRODUCTS & FURNITU | 70 | 79 | 89 | 100 | 112 | 126 | 171 | 215 | 262 | 323 | 398 |
| PAPER & ALLIED PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRINTING & PUBLISHING | 83 | 88 | 94 | 100 | 106 | 113 | 140 | 171 | 200 | 261 | 327 |
| CHEMICALS & ALLIED PRODUC | 75 | 82 | 91 | 100 | 110 | 121 | 156 | 204 | 264 | 344 | 449 |
| PETROLEUM REFINING | 82 | 88 | 94 | 100 | 107 | 114 | 135 | 159 | 187 | 223 | 264 |
| PRIMARY METALS | 92 | 95 | 97 | 100 | 103 | 106 | 118 | 133 | 152 | 174 | 199 |
| FABRICATED METALS & ORDNA | 79 | 85 | 92 | 100 | 108 | 117 | 157 | 192 | 236 | 293 | 363 |
| MACHINERY, EXCLUDING ELEC | 84 | 89 | 94 | 100 | 106 | 112 | 138 | 171 | 210 | 261 | 324 |
| ELECTRICAL MACHINERY & SU | 72 | 81 | 90 | 100 | 111 | 124 | 196 | 257 | 332 | 434 | 568 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 69 | 78 | 89 | 100 | 113 | 128 | 166 | 195 | 229 | 273 | 324 |
| OTHER MANUFACTURING | 85 | 90 | 95 | 100 | 106 | 111 | 146 | 187 | 238 | 304 | 388 |
| POPULATION (SERIES C-150) | 98 | 99 | 100 | 100 | 100 | 102 | 109 | 117 | 125 | 132 | 139 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 96 | 97 | 99 | 100 | 101 | 103 | 110 | 117 | 125 | 132 | 140 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 96 | 98 | 99 | 100 | 101 | 102 | 108 | 114 | 120 | 126 | 132 |
| NONMETALLIC, EXCEPT FUELS | 92 | 95 | 97 | 100 | 103 | 105 | 119 | 134 | 150 | 166 | 183 |
| CONTRACT CONSTRUCTION | 88 | 92 | 96 | 100 | 104 | 109 | 133 | 160 | 191 | 226 | 264 |
| MANUFACTURING | 89 | 92 | 96 | 100 | 104 | 108 | 130 | 155 | 183 | 213 | 247 |
| FOOD & KINDRED PRODUCTS | 92 | 95 | 97 | 100 | 103 | 105 | 119 | 134 | 150 | 167 | 184 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 84 | 89 | 95 | 100 | 106 | 112 | 145 | 186 | 234 | 292 | 360 |
| LUMBER PRODUCTS & FURNITU | 86 | 91 | 95 | 100 | 105 | 110 | 138 | 170 | 208 | 251 | 301 |
| PAPER & ALLIED PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRINTING & PUBLISHING | 88 | 92 | 96 | 100 | 104 | 109 | 132 | 159 | 189 | 222 | 260 |
| CHEMICALS & ALLIED PRODUC | 89 | 93 | 96 | 100 | 104 | 108 | 129 | 152 | 178 | 207 | 238 |
| PETROLEUM REFINING | 95 | 97 | 98 | 100 | 102 | 103 | 111 | 119 | 128 | 136 | 144 |
| PRIMARY METALS | 94 | 96 | 98 | 100 | 102 | 104 | 113 | 123 | 133 | 143 | 153 |
| FABRICATED METALS & ORDNA | 89 | 92 | 96 | 100 | 104 | 108 | 130 | 155 | 183 | 215 | 249 |
| MACHINERY, EXCLUDING ELEC | 91 | 94 | 97 | 100 | 103 | 107 | 124 | 143 | 164 | 186 | 210 |
| ELECTRICAL MACHINERY & SU | 82 | 87 | 94 | 100 | 107 | 114 | 156 | 208 | 275 | 357 | 437 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 120 | 129 | 138 | 147 |
| OTHER MANUFACTURING | 85 | 90 | 95 | 100 | 105 | 111 | 143 | 181 | 227 | 280 | 343 |
| POPULATION (SERIES E-0) | 98 | 99 | 100 | 100 | 100 | 102 | 106 | 110 | 114 | 117 | 119 |

TABLE B.3.7

# LOS ANGELES COUNTY - Los Angeles-Long Beach SMSA

## SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 102 | 101 | 101 | 100 | 99 | 99 | 100 | 105 | 110 | 120 | 130 |
| FORESTRY & FISHERIES | 94 | 96 | 98 | 100 | 102 | 104 | 122 | 134 | 149 | 166 | 185 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 90 | 93 | 96 | 100 | 104 | 107 | 119 | 130 | 142 | 155 | 169 |
| NONMETALLIC, EXCEPT FUELS | 91 | 94 | 97 | 100 | 103 | 106 | 127 | 144 | 163 | 187 | 215 |
| CONTRACT CONSTRUCTION | 86 | 90 | 95 | 100 | 105 | 111 | 139 | 172 | 212 | 266 | 333 |
| MANUFACTURING | 81 | 87 | 93 | 100 | 107 | 115 | 140 | 169 | 203 | 249 | 305 |
| FOOD & KINDRED PRODUCTS | 85 | 90 | 95 | 100 | 106 | 111 | 132 | 152 | 176 | 204 | 236 |
| TEXTILE MILL PRODUCTS | 82 | 88 | 94 | 100 | 107 | 114 | 137 | 161 | 188 | 223 | 263 |
| APPAREL & OTHER FABRIC PR | 83 | 88 | 94 | 100 | 107 | 114 | 139 | 164 | 193 | 230 | 274 |
| LUMBER PRODUCTS & FURNITU | 76 | 84 | 91 | 100 | 109 | 120 | 141 | 162 | 186 | 215 | 248 |
| PAPER & ALLIED PRODUCTS | 85 | 89 | 95 | 100 | 106 | 112 | 135 | 161 | 192 | 232 | 281 |
| PRINTING & PUBLISHING | 85 | 89 | 95 | 100 | 106 | 112 | 139 | 170 | 208 | 256 | 315 |
| CHEMICALS & ALLIED PRODUC | 79 | 86 | 93 | 100 | 108 | 117 | 150 | 190 | 240 | 306 | 389 |
| PETROLEUM REFINING | 94 | 96 | 98 | 100 | 102 | 104 | 121 | 139 | 160 | 185 | 214 |
| PRIMARY METALS | 81 | 87 | 93 | 100 | 107 | 115 | 130 | 146 | 164 | 185 | 209 |
| FABRICATED METALS & ORDNA | 77 | 84 | 92 | 100 | 109 | 119 | 150 | 186 | 230 | 287 | 359 |
| MACHINERY, EXCLUDING ELEC | 85 | 90 | 95 | 100 | 105 | 111 | 134 | 159 | 190 | 231 | 282 |
| ELECTRICAL MACHINERY & SU | 81 | 87 | 93 | 100 | 107 | 115 | 145 | 184 | 232 | 297 | 381 |
| MOTOR VEHICLES & EQUIPMEN | 84 | 89 | 94 | 100 | 106 | 112 | 116 | 136 | 159 | 189 | 225 |
| TRANS. EQUIP., EXCL. MTR. | 73 | 81 | 90 | 100 | 111 | 124 | 152 | 176 | 202 | 238 | 279 |
| OTHER MANUFACTURING | 86 | 91 | 95 | 100 | 105 | 110 | 137 | 167 | 204 | 252 | 311 |
| POPULATION (SERIES C-150) | 101 | 102 | 100 | 100 | 100 | 100 | 101 | 105 | 109 | 114 | 120 |

## SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 121 | 130 | 140 | 149 |
| FORESTRY & FISHERIES | 94 | 96 | 98 | 100 | 102 | 104 | 115 | 126 | 137 | 149 | 161 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 97 | 98 | 99 | 100 | 101 | 102 | 106 | 111 | 115 | 120 | 124 |
| NONMETALLIC, EXCEPT FUELS | 95 | 97 | 98 | 100 | 102 | 103 | 111 | 119 | 127 | 135 | 144 |
| CONTRACT CONSTRUCTION | 89 | 92 | 96 | 100 | 104 | 108 | 129 | 154 | 180 | 210 | 243 |
| MANUFACTURING | 90 | 94 | 97 | 100 | 103 | 107 | 125 | 144 | 165 | 188 | 213 |
| FOOD & KINDRED PRODUCTS | 93 | 96 | 98 | 100 | 102 | 104 | 116 | 128 | 141 | 153 | 167 |
| TEXTILE MILL PRODUCTS | 88 | 92 | 96 | 100 | 104 | 109 | 134 | 162 | 194 | 230 | 270 |
| APPAREL & OTHER FABRIC PR | 89 | 92 | 96 | 100 | 104 | 108 | 129 | 153 | 180 | 209 | 242 |
| LUMBER PRODUCTS & FURNITU | 92 | 94 | 97 | 100 | 103 | 106 | 121 | 138 | 155 | 174 | 194 |
| PAPER & ALLIED PRODUCTS | 89 | 93 | 96 | 100 | 104 | 108 | 128 | 151 | 176 | 203 | 234 |
| PRINTING & PUBLISHING | 89 | 93 | 96 | 100 | 104 | 108 | 129 | 153 | 179 | 208 | 239 |
| CHEMICALS & ALLIED PRODUC | 87 | 91 | 95 | 100 | 105 | 110 | 136 | 168 | 204 | 245 | 291 |
| PETROLEUM REFINING | 92 | 94 | 97 | 100 | 103 | 106 | 121 | 138 | 155 | 174 | 193 |
| PRIMARY METALS | 96 | 97 | 99 | 100 | 101 | 103 | 109 | 116 | 122 | 129 | 135 |
| FABRICATED METALS & ORDNA | 91 | 94 | 97 | 100 | 103 | 106 | 122 | 138 | 156 | 175 | 196 |
| MACHINERY, EXCLUDING ELEC | 91 | 94 | 97 | 100 | 103 | 107 | 124 | 143 | 164 | 186 | 210 |
| ELECTRICAL MACHINERY & SU | 88 | 92 | 96 | 100 | 104 | 109 | 133 | 161 | 192 | 227 | 266 |
| MOTOR VEHICLES & EQUIPMEN | 90 | 93 | 97 | 100 | 104 | 107 | 127 | 148 | 171 | 197 | 225 |
| TRANS. EQUIP., EXCL. MTR. | 96 | 97 | 99 | 100 | 101 | 103 | 109 | 116 | 123 | 130 | 136 |
| OTHER MANUFACTURING | 88 | 92 | 96 | 100 | 104 | 108 | 131 | 158 | 187 | 220 | 256 |
| POPULATION (SERIES E-0) | 101 | 102 | 100 | 100 | 100 | 100 | 96 | 94 | 94 | 94 | 94 |

TABLE B.3.8

MONTEREY COUNTY - Salinas, Monterey SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 92 | 95 | 97 | 100 | 103 | 105 | 110 | 111 | 112 | 121 | 132 |
| FORESTRY & FISHERIES | 83 | 88 | 94 | 100 | 106 | 113 | 156 | 170 | 190 | 225 | 255 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 92 | 95 | 97 | 100 | 103 | 106 | 127 | 143 | 160 | 183 | 209 |
| NONMETALLIC, EXCEPT FUELS | 102 | 101 | 101 | 100 | 99 | 99 | 102 | 116 | 132 | 153 | 178 |
| CONTRACT CONSTRUCTION | 74 | 82 | 90 | 100 | 111 | 123 | 163 | 205 | 258 | 326 | 413 |
| MANUFACTURING | 81 | 87 | 93 | 100 | 107 | 115 | 152 | 191 | 241 | 304 | 385 |
| FOOD & KINDRED PRODUCTS | 89 | 92 | 96 | 100 | 104 | 108 | 130 | 153 | 180 | 212 | 250 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 66 | 76 | 87 | 100 | 115 | 132 | 178 | 220 | 263 | 318 | 386 |
| LUMBER PRODUCTS & FURNITU | 73 | 81 | 90 | 100 | 111 | 123 | 144 | 163 | 194 | 227 | 265 |
| PAPER & ALLIED PRODUCTS | 75 | 83 | 91 | 100 | 110 | 121 | 162 | 201 | 247 | 307 | 382 |
| PRINTING & PUBLISHING | 85 | 90 | 95 | 100 | 106 | 111 | 153 | 201 | 262 | 343 | 442 |
| CHEMICALS & ALLIED PRODUC | 80 | 86 | 93 | 100 | 103 | 116 | 151 | 189 | 239 | 302 | 382 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| FABRICATED METALS & ORDNA | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MACHINERY, EXCLUDING ELEC | 105 | 104 | 102 | 100 | 98 | 97 | 127 | 168 | 224 | 296 | 390 |
| ELECTRICAL MACHINERY & SU | 50 | 63 | 79 | 100 | 126 | 159 | 262 | 333 | 428 | 560 | 715 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| OTHER MANUFACTURING | 74 | 82 | 90 | 100 | 111 | 122 | 178 | 236 | 314 | 413 | 545 |
| POPULATION (SERIES C-150) | 97 | 100 | 99 | 100 | 102 | 104 | 119 | 134 | 151 | 169 | 187 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 95 | 97 | 98 | 100 | 102 | 103 | 111 | 119 | 127 | 135 | 143 |
| FORESTRY & FISHERIES | 93 | 95 | 97 | 100 | 103 | 105 | 118 | 132 | 147 | 163 | 179 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 141 | 161 | 182 | 204 |
| NONMETALLIC, EXCEPT FUELS | 95 | 96 | 98 | 100 | 102 | 104 | 113 | 122 | 131 | 140 | 150 |
| CONTRACT CONSTRUCTION | 87 | 91 | 95 | 100 | 105 | 110 | 136 | 168 | 203 | 244 | 291 |
| MANUFACTURING | 86 | 91 | 95 | 100 | 105 | 110 | 137 | 169 | 207 | 249 | 298 |
| FOOD & KINDRED PRODUCTS | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 141 | 160 | 180 | 202 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 89 | 93 | 96 | 100 | 104 | 108 | 139 | 153 | 179 | 208 | 239 |
| LUMBER PRODUCTS & FURNITU | 92 | 94 | 97 | 100 | 103 | 106 | 121 | 138 | 156 | 175 | 195 |
| PAPER & ALLIED PRODUCTS | 88 | 92 | 96 | 100 | 104 | 109 | 132 | 159 | 190 | 224 | 262 |
| PRINTING & PUBLISHING | 84 | 89 | 94 | 100 | 105 | 112 | 147 | 189 | 241 | 307 | 375 |
| CHEMICALS & ALLIED PRODUC | 86 | 91 | 95 | 100 | 105 | 110 | 138 | 172 | 211 | 255 | 306 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 91 | 94 | 97 | 100 | 103 | 106 | 122 | 140 | 159 | 179 | 200 |
| FABRICATED METALS & ORDNA | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MACHINERY, EXCLUDING ELEC | 86 | 90 | 95 | 100 | 105 | 111 | 140 | 176 | 217 | 265 | 321 |
| ELECTRICAL MACHINERY & SU | 88 | 92 | 96 | 100 | 104 | 109 | 134 | 162 | 194 | 231 | 272 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 94 | 96 | 98 | 100 | 102 | 104 | 114 | 125 | 136 | 147 | 157 |
| OTHER MANUFACTURING | 84 | 89 | 94 | 100 | 106 | 112 | 147 | 189 | 241 | 307 | 375 |
| POPULATION (SERIES E-0) | 97 | 100 | 99 | 100 | 102 | 104 | 114 | 121 | 129 | 136 | 142 |

# TABLE B.3.9
## ORANGE COUNTY - Anaheim-Santa Ana-Garden Grove SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 96 | 97 | 99 | 100 | 102 | 103 | 107 | 113 | 118 | 128 | 139 |
| FORESTRY & FISHERIES | 99 | 100 | 100 | 100 | 100 | 100 | 120 | 130 | 141 | 155 | 171 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 90 | 93 | 97 | 100 | 104 | 107 | 118 | 128 | 140 | 153 | 167 |
| NONMETALLIC, EXCEPT FUELS | 111 | 107 | 104 | 100 | 97 | 93 | 119 | 140 | 164 | 196 | 233 |
| CONTRACT CONSTRUCTION | 86 | 90 | 95 | 100 | 105 | 111 | 137 | 171 | 213 | 268 | 337 |
| MANUFACTURING | 79 | 85 | 92 | 100 | 108 | 117 | 157 | 199 | 254 | 324 | 412 |
| FOOD & KINDRED PRODUCTS | 86 | 91 | 95 | 100 | 105 | 110 | 139 | 167 | 200 | 240 | 288 |
| TEXTILE MILL PRODUCTS | 90 | 93 | 96 | 100 | 104 | 108 | 136 | 170 | 211 | 262 | 324 |
| APPAREL & OTHER FABRIC PR | 85 | 89 | 95 | 100 | 106 | 112 | 141 | 174 | 216 | 269 | 334 |
| LUMBER PRODUCTS & FURNITU | 73 | 81 | 90 | 100 | 111 | 123 | 158 | 192 | 235 | 286 | 348 |
| PAPER & ALLIED PRODUCTS | 83 | 88 | 94 | 100 | 106 | 113 | 145 | 181 | 226 | 283 | 356 |
| PRINTING & PUBLISHING | 85 | 90 | 95 | 100 | 106 | 112 | 146 | 182 | 227 | 285 | 356 |
| CHEMICALS & ALLIED PRODUC | 82 | 87 | 93 | 100 | 107 | 114 | 168 | 226 | 304 | 405 | 541 |
| PETROLEUM REFINING | 84 | 89 | 94 | 100 | 106 | 113 | 140 | 169 | 203 | 244 | 294 |
| PRIMARY METALS | 82 | 88 | 94 | 100 | 107 | 114 | 125 | 146 | 170 | 198 | 231 |
| FABRICATED METALS & ORDNA | 80 | 87 | 93 | 100 | 108 | 116 | 156 | 202 | 261 | 336 | 434 |
| MACHINERY, EXCLUDING ELEC | 82 | 87 | 93 | 100 | 107 | 114 | 146 | 185 | 233 | 295 | 373 |
| ELECTRICAL MACHINERY & SU | 73 | 81 | 90 | 100 | 111 | 123 | 168 | 216 | 279 | 359 | 460 |
| MOTOR VEHICLES & EQUIPMEN | 97 | 98 | 99 | 100 | 101 | 102 | 101 | 118 | 137 | 163 | 194 |
| TRANS. EQUIP., EXCL. MTR. | 80 | 86 | 93 | 100 | 108 | 116 | 147 | 180 | 220 | 270 | 332 |
| OTHER MANUFACTURING | 87 | 91 | 95 | 100 | 105 | 110 | 143 | 181 | 228 | 290 | 368 |
| POPULATION (SERIES C-150) | 90 | 92 | 96 | 100 | 104 | 106 | 125 | 146 | 165 | 180 | 193 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 121 | 130 | 140 | 149 |
| FORESTRY & FISHERIES | 95 | 97 | 98 | 100 | 102 | 103 | 111 | 118 | 126 | 134 | 142 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 97 | 98 | 99 | 100 | 101 | 102 | 106 | 111 | 115 | 120 | 124 |
| NONMETALLIC, EXCEPT FUELS | 93 | 95 | 98 | 100 | 102 | 105 | 118 | 131 | 145 | 159 | 174 |
| CONTRACT CONSTRUCTION | 89 | 92 | 96 | 100 | 104 | 108 | 130 | 155 | 183 | 215 | 249 |
| MANUFACTURING | 88 | 92 | 96 | 100 | 104 | 109 | 132 | 158 | 188 | 222 | 259 |
| FOOD & KINDRED PRODUCTS | 91 | 94 | 97 | 100 | 103 | 106 | 122 | 140 | 159 | 179 | 200 |
| TEXTILE MILL PRODUCTS | 85 | 89 | 95 | 100 | 106 | 111 | 144 | 184 | 232 | 288 | 353 |
| APPAREL & OTHER FABRIC PR | 86 | 90 | 95 | 100 | 105 | 110 | 139 | 173 | 213 | 258 | 311 |
| LUMBER PRODUCTS & FURNITU | 88 | 92 | 96 | 100 | 104 | 108 | 132 | 158 | 188 | 221 | 258 |
| PAPER & ALLIED PRODUCTS | 87 | 91 | 95 | 100 | 105 | 109 | 136 | 166 | 201 | 241 | 286 |
| PRINTING & PUBLISHING | 88 | 92 | 96 | 100 | 104 | 109 | 133 | 160 | 190 | 225 | 263 |
| CHEMICALS & ALLIED PRODUC | 84 | 89 | 94 | 100 | 106 | 112 | 147 | 191 | 243 | 305 | 379 |
| PETROLEUM REFINING | 89 | 93 | 96 | 100 | 104 | 108 | 129 | 152 | 178 | 207 | 238 |
| PRIMARY METALS | 94 | 96 | 98 | 100 | 102 | 104 | 115 | 126 | 137 | 149 | 161 |
| FABRICATED METALS & ORDNA | 89 | 93 | 96 | 100 | 104 | 108 | 128 | 151 | 176 | 204 | 234 |
| MACHINERY, EXCLUDING ELEC | 88 | 92 | 96 | 100 | 104 | 109 | 132 | 159 | 190 | 224 | 262 |
| ELECTRICAL MACHINERY & SU | 88 | 92 | 96 | 100 | 104 | 109 | 134 | 162 | 194 | 230 | 271 |
| MOTOR VEHICLES & EQUIPMEN | 90 | 93 | 96 | 100 | 104 | 107 | 127 | 148 | 172 | 198 | 226 |
| TRANS. EQUIP., EXCL. MTR. | 93 | 95 | 98 | 100 | 102 | 105 | 118 | 132 | 146 | 161 | 177 |
| OTHER MANUFACTURING | 87 | 91 | 95 | 100 | 105 | 110 | 137 | 169 | 206 | 248 | 296 |
| POPULATION (SERIES E-0) | 90 | 92 | 96 | 100 | 104 | 106 | 119 | 130 | 138 | 144 | 149 |

TABLE B.3.10

RIVERSIDE & SAN BERNARDINO COUNTIES - Riverside-San Bernardino-Ontario SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 94 | 96 | 98 | 100 | 102 | 104 | 107 | 112 | 118 | 128 | 138 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 93 | 96 | 98 | 100 | 102 | 105 | 118 | 138 | 163 | 191 | 225 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 91 | 94 | 97 | 100 | 103 | 107 | 129 | 152 | 179 | 213 | 253 |
| CONTRACT CONSTRUCTION | 85 | 89 | 95 | 100 | 106 | 112 | 149 | 192 | 248 | 321 | 414 |
| MANUFACTURING | 84 | 89 | 94 | 100 | 106 | 113 | 138 | 167 | 203 | 249 | 305 |
| FOOD & KINDRED PRODUCTS | 91 | 94 | 97 | 100 | 103 | 106 | 126 | 140 | 174 | 205 | 242 |
| TEXTILE MILL PRODUCTS | 111 | 107 | 104 | 100 | 97 | 93 | 102 | 125 | 155 | 192 | 236 |
| APPAREL & OTHER FABRIC PR | 72 | 80 | 90 | 100 | 112 | 125 | 178 | 224 | 283 | 356 | 447 |
| LUMBER PRODUCTS & FURNITU | 74 | 82 | 90 | 100 | 111 | 122 | 159 | 197 | 242 | 295 | 359 |
| PAPER & ALLIED PRODUCTS | 81 | 87 | 93 | 100 | 107 | 115 | 147 | 186 | 234 | 296 | 375 |
| PRINTING & PUBLISHING | 82 | 88 | 94 | 100 | 107 | 114 | 152 | 190 | 238 | 299 | 376 |
| CHEMICALS & ALLIED PRODUC | 85 | 90 | 95 | 100 | 106 | 111 | 137 | 163 | 206 | 254 | 315 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 82 | 88 | 94 | 100 | 107 | 114 | 130 | 147 | 167 | 192 | 220 |
| FABRICATED METALS & ORDNA | 85 | 89 | 95 | 100 | 106 | 112 | 155 | 204 | 269 | 353 | 462 |
| MACHINERY, EXCLUDING ELEC | 89 | 92 | 96 | 100 | 104 | 108 | 130 | 158 | 192 | 236 | 291 |
| ELECTRICAL MACHINERY & SU | 76 | 83 | 91 | 100 | 110 | 120 | 172 | 231 | 310 | 411 | 545 |
| MOTOR VEHICLES & EQUIPMEN | 112 | 108 | 104 | 100 | 96 | 93 | 63 | 73 | 86 | 103 | 124 |
| TRANS. EQUIP., EXCL. MTR. | 74 | 82 | 90 | 100 | 111 | 122 | 159 | 192 | 232 | 282 | 343 |
| OTHER MANUFACTURING | 97 | 98 | 99 | 100 | 101 | 102 | 115 | 138 | 166 | 203 | 248 |
| POPULATION (SERIES C-150) | 96 | 98 | 99 | 100 | 101 | 103 | 116 | 131 | 147 | 163 | 178 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 121 | 130 | 140 | 149 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 94 | 96 | 98 | 100 | 102 | 104 | 114 | 124 | 134 | 145 | 156 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 93 | 95 | 98 | 100 | 103 | 105 | 117 | 130 | 144 | 159 | 173 |
| CONTRACT CONSTRUCTION | 87 | 91 | 95 | 100 | 105 | 110 | 136 | 167 | 203 | 243 | 289 |
| MANUFACTURING | 90 | 93 | 97 | 100 | 103 | 107 | 125 | 146 | 168 | 192 | 218 |
| FOOD & KINDRED PRODUCTS | 92 | 95 | 97 | 100 | 103 | 105 | 119 | 134 | 150 | 166 | 183 |
| TEXTILE MILL PRODUCTS | 85 | 90 | 95 | 100 | 106 | 111 | 143 | 182 | 228 | 283 | 346 |
| APPAREL & OTHER FABRIC PR | 86 | 90 | 95 | 100 | 105 | 111 | 141 | 176 | 218 | 267 | 324 |
| LUMBER PRODUCTS & FURNITU | 88 | 92 | 96 | 100 | 104 | 109 | 133 | 160 | 191 | 225 | 264 |
| PAPER & ALLIED PRODUCTS | 86 | 91 | 95 | 100 | 105 | 110 | 138 | 171 | 208 | 252 | 302 |
| PRINTING & PUBLISHING | 88 | 92 | 96 | 100 | 104 | 109 | 133 | 161 | 193 | 229 | 269 |
| CHEMICALS & ALLIED PRODUC | 89 | 92 | 96 | 100 | 104 | 108 | 130 | 155 | 182 | 213 | 247 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 95 | 97 | 98 | 100 | 102 | 103 | 111 | 120 | 128 | 137 | 145 |
| FABRICATED METALS & ORDNA | 88 | 92 | 96 | 100 | 104 | 108 | 131 | 157 | 187 | 219 | 256 |
| MACHINERY, EXCLUDING ELEC | 90 | 93 | 97 | 100 | 104 | 107 | 126 | 148 | 171 | 196 | 224 |
| ELECTRICAL MACHINERY & SU | 86 | 90 | 95 | 100 | 105 | 111 | 141 | 176 | 218 | 266 | 322 |
| MOTOR VEHICLES & EQUIPMEN | 90 | 93 | 96 | 100 | 104 | 107 | 127 | 149 | 173 | 199 | 227 |
| TRANS. EQUIP., EXCL. MTR. | 93 | 96 | 98 | 100 | 103 | 104 | 116 | 128 | 140 | 153 | 166 |
| OTHER MANUFACTURING | 89 | 93 | 96 | 100 | 104 | 108 | 129 | 152 | 178 | 206 | 238 |
| POPULATION (SERIES E-0) | 96 | 98 | 99 | 100 | 101 | 103 | 111 | 119 | 126 | 133 | 139 |

TABLE B.3.11

NAPA & SOLANO COUNTIES - Vallejo-Fairfield-Napa SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 91 | 94 | 97 | 100 | 103 | 106 | 109 | 114 | 118 | 129 | 140 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 89 | 93 | 96 | 100 | 104 | 108 | 132 | 149 | 168 | 188 | 211 |
| NONMETALLIC, EXCEPT FUELS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CONTRACT CONSTRUCTION | 77 | 84 | 91 | 100 | 109 | 120 | 161 | 209 | 272 | 353 | 457 |
| MANUFACTURING | 88 | 92 | 96 | 100 | 104 | 109 | 134 | 159 | 190 | 229 | 276 |
| FOOD & KINDRED PRODUCTS | 87 | 91 | 95 | 100 | 105 | 110 | 131 | 152 | 177 | 206 | 241 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 87 | 91 | 95 | 100 | 105 | 110 | 127 | 148 | 171 | 202 | 237 |
| LUMBER PRODUCTS & FURNITU | 74 | 82 | 90 | 100 | 111 | 123 | 177 | 220 | 277 | 331 | 395 |
| PAPER & ALLIED PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRINTING & PUBLISHING | 77 | 84 | 92 | 100 | 109 | 119 | 166 | 220 | 291 | 385 | 509 |
| CHEMICALS & ALLIED PRODUC | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PETROLEUM REFINING | 116 | 110 | 105 | 100 | 95 | 91 | 97 | 123 | 157 | 196 | 245 |
| PRIMARY METALS | 67 | 76 | 87 | 100 | 115 | 131 | 160 | 182 | 206 | 235 | 269 |
| FABRICATED METALS & ORDNA | 88 | 92 | 96 | 100 | 104 | 109 | 137 | 170 | 210 | 263 | 329 |
| MACHINERY, EXCLUDING ELEC | 68 | 77 | 88 | 100 | 114 | 129 | 176 | 222 | 280 | 355 | 452 |
| ELECTRICAL MACHINERY & SU | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| OTHER MANUFACTURING | 92 | 95 | 97 | 100 | 103 | 106 | 129 | 156 | 188 | 230 | 281 |
| POPULATION (SERIES C-150) | 95 | 98 | 100 | 100 | 102 | 103 | 116 | 133 | 155 | 179 | 207 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 121 | 130 | 139 | 149 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 91 | 94 | 97 | 100 | 103 | 106 | 124 | 142 | 162 | 184 | 207 |
| NONMETALLIC, EXCEPT FUELS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CONTRACT CONSTRUCTION | 85 | 90 | 95 | 100 | 105 | 111 | 141 | 178 | 221 | 271 | 329 |
| MANUFACTURING | 89 | 93 | 96 | 100 | 104 | 107 | 128 | 150 | 175 | 202 | 232 |
| FOOD & KINDRED PRODUCTS | 92 | 94 | 97 | 100 | 103 | 106 | 121 | 137 | 154 | 172 | 191 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 91 | 94 | 97 | 100 | 103 | 106 | 122 | 138 | 156 | 176 | 196 |
| LUMBER PRODUCTS & FURNITU | 89 | 93 | 96 | 100 | 104 | 108 | 129 | 153 | 179 | 209 | 241 |
| PAPER & ALLIED PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRINTING & PUBLISHING | 83 | 88 | 94 | 100 | 106 | 113 | 150 | 196 | 252 | 319 | 400 |
| CHEMICALS & ALLIED PRODUC | 91 | 94 | 97 | 100 | 103 | 106 | 122 | 139 | 157 | 177 | 198 |
| PETROLEUM REFINING | 86 | 91 | 95 | 100 | 105 | 110 | 138 | 171 | 209 | 253 | 303 |
| PRIMARY METALS | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 121 | 130 | 139 | 148 |
| FABRICATED METALS & ORDNA | 90 | 93 | 97 | 100 | 103 | 107 | 125 | 145 | 167 | 191 | 217 |
| MACHINERY, EXCLUDING ELEC | 88 | 92 | 96 | 100 | 104 | 109 | 132 | 159 | 190 | 224 | 262 |
| ELECTRICAL MACHINERY & SU | 85 | 90 | 95 | 100 | 106 | 111 | 144 | 183 | 230 | 285 | 349 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| OTHER MANUFACTURING | 89 | 92 | 96 | 100 | 104 | 108 | 130 | 155 | 182 | 213 | 247 |
| POPULATION (SERIES E-0) | 95 | 98 | 100 | 100 | 102 | 103 | 110 | 117 | 124 | 130 | 135 |

# TABLE B.3.12
## SACRAMENTO - YOLO-PLACER COUNTIES - Sacramento SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 94 | 96 | 98 | 100 | 102 | 104 | 104 | 106 | 109 | 117 | 127 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 31 | 46 | 68 | 100 | 147 | 216 | 353 | 409 | 464 | 520 | 601 |
| CONTRACT CONSTRUCTION | 89 | 92 | 96 | 100 | 104 | 108 | 131 | 161 | 193 | 247 | 307 |
| MANUFACTURING | 80 | 86 | 93 | 100 | 108 | 116 | 141 | 170 | 204 | 248 | 301 |
| FOOD & KINDRED PRODUCTS | 88 | 92 | 96 | 100 | 104 | 109 | 128 | 147 | 168 | 193 | 223 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 88 | 92 | 96 | 100 | 104 | 109 | 144 | 168 | 215 | 259 | 312 |
| LUMBER PRODUCTS & FURNITU | 77 | 84 | 92 | 100 | 109 | 119 | 143 | 167 | 194 | 227 | 265 |
| PAPER & ALLIED PRODUCTS | 91 | 94 | 97 | 100 | 103 | 107 | 139 | 178 | 220 | 274 | 378 |
| PRINTING & PUBLISHING | 82 | 88 | 94 | 100 | 107 | 114 | 146 | 182 | 227 | 286 | 360 |
| CHEMICALS & ALLIED PRODUC | 71 | 80 | 89 | 100 | 112 | 125 | 174 | 234 | 314 | 421 | 564 |
| PETROLEUM REFINING | 95 | 97 | 98 | 100 | 102 | 103 | 121 | 138 | 162 | 188 | 220 |
| PRIMARY METALS | 95 | 97 | 98 | 100 | 102 | 104 | 110 | 120 | 130 | 144 | 159 |
| FABRICATED METALS & ORDNA | 68 | 78 | 88 | 100 | 114 | 129 | 166 | 205 | 261 | 329 | 415 |
| MACHINERY, EXCLUDING ELEC | 84 | 89 | 94 | 100 | 106 | 112 | 143 | 180 | 225 | 283 | 356 |
| ELECTRICAL MACHINERY & SU | 85 | 89 | 95 | 100 | 106 | 113 | 150 | 190 | 241 | 291 | 352 |
| MOTOR VEHICLES & EQUIPMEN | 115 | 110 | 105 | 100 | 95 | 91 | 59 | 74 | 94 | 122 | 158 |
| TRANS. EQUIP., EXCL. MTR. | 72 | 80 | 90 | 100 | 112 | 125 | 157 | 183 | 211 | 248 | 293 |
| OTHER MANUFACTURING | 84 | 89 | 94 | 100 | 106 | 113 | 142 | 175 | 217 | 270 | 337 |
| POPULATION (SERIES C-150) | 95 | 96 | 98 | 100 | 102 | 103 | 117 | 131 | 144 | 156 | 169 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 96 | 97 | 99 | 100 | 101 | 103 | 109 | 116 | 123 | 130 | 136 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CONTRACT CONSTRUCTION | 88 | 92 | 96 | 100 | 104 | 108 | 131 | 156 | 184 | 215 | 250 |
| MANUFACTURING | 91 | 94 | 97 | 100 | 103 | 106 | 124 | 142 | 163 | 184 | 208 |
| FOOD & KINDRED PRODUCTS | 93 | 95 | 98 | 100 | 102 | 105 | 117 | 129 | 142 | 156 | 170 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 87 | 91 | 95 | 100 | 105 | 110 | 137 | 168 | 205 | 246 | 294 |
| LUMBER PRODUCTS & FURNITU | 89 | 93 | 96 | 100 | 104 | 108 | 129 | 153 | 180 | 209 | 242 |
| PAPER & ALLIED PRODUCTS | 87 | 92 | 96 | 100 | 104 | 109 | 134 | 163 | 195 | 232 | 273 |
| PRINTING & PUBLISHING | 87 | 91 | 95 | 100 | 105 | 110 | 136 | 168 | 204 | 245 | 291 |
| CHEMICALS & ALLIED PRODUC | 88 | 92 | 96 | 100 | 104 | 108 | 131 | 156 | 184 | 216 | 251 |
| PETROLEUM REFINING | 90 | 93 | 97 | 100 | 103 | 107 | 125 | 145 | 167 | 191 | 216 |
| PRIMARY METALS | 94 | 96 | 98 | 100 | 102 | 104 | 113 | 123 | 133 | 143 | 153 |
| FABRICATED METALS & ORDNA | 92 | 95 | 97 | 100 | 103 | 105 | 119 | 134 | 150 | 166 | 183 |
| MACHINERY, EXCLUDING ELEC | 90 | 93 | 97 | 100 | 104 | 107 | 126 | 147 | 171 | 196 | 223 |
| ELECTRICAL MACHINERY & SU | 83 | 88 | 94 | 100 | 106 | 113 | 151 | 195 | 250 | 329 | 415 |
| MOTOR VEHICLES & EQUIPMEN | 88 | 92 | 96 | 100 | 104 | 109 | 132 | 160 | 190 | 225 | 263 |
| TRANS. EQUIP., EXCL. MTR. | 95 | 97 | 98 | 100 | 102 | 103 | 111 | 120 | 128 | 136 | 145 |
| OTHER MANUFACTURING | 87 | 91 | 95 | 100 | 105 | 110 | 136 | 168 | 203 | 244 | 291 |
| POPULATION (SERIES E-0) | 95 | 96 | 98 | 100 | 102 | 103 | 112 | 118 | 124 | 129 | 133 |

# TABLE B.3.13

## SAN DIEGO COUNTY - San Diego SMSA

### SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 97 | 98 | 99 | 100 | 101 | 102 | 102 | 105 | 108 | 117 | 127 |
| FORESTRY & FISHERIES | 95 | 97 | 98 | 100 | 102 | 104 | 121 | 132 | 144 | 160 | 178 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 92 | 95 | 97 | 100 | 103 | 106 | 130 | 152 | 177 | 211 | 250 |
| CONTRACT CONSTRUCTION | 88 | 92 | 96 | 100 | 104 | 109 | 131 | 160 | 196 | 242 | 299 |
| MANUFACTURING | 82 | 88 | 94 | 100 | 107 | 114 | 144 | 178 | 221 | 276 | 344 |
| FOOD & KINDRED PRODUCTS | 88 | 92 | 96 | 100 | 104 | 109 | 128 | 150 | 175 | 206 | 242 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 80 | 86 | 93 | 100 | 108 | 116 | 146 | 177 | 214 | 262 | 320 |
| LUMBER PRODUCTS & FURNITU | 77 | 84 | 92 | 100 | 109 | 119 | 148 | 177 | 210 | 251 | 300 |
| PAPER & ALLIED PRODUCTS | 84 | 89 | 94 | 100 | 106 | 113 | 145 | 186 | 238 | 301 | 381 |
| PRINTING & PUBLISHING | 89 | 93 | 96 | 100 | 104 | 108 | 133 | 163 | 199 | 247 | 305 |
| CHEMICALS & ALLIED PRODUC | 91 | 94 | 97 | 100 | 103 | 106 | 125 | 144 | 166 | 196 | 232 |
| PETROLEUM REFINING | 92 | 95 | 97 | 100 | 103 | 105 | 127 | 150 | 177 | 211 | 253 |
| PRIMARY METALS | 77 | 84 | 92 | 100 | 109 | 119 | 129 | 135 | 140 | 151 | 164 |
| FABRICATED METALS & ORDNA | 82 | 88 | 94 | 100 | 107 | 114 | 138 | 168 | 205 | 252 | 309 |
| MACHINERY, EXCLUDING ELEC | 95 | 97 | 98 | 100 | 102 | 103 | 132 | 166 | 209 | 266 | 338 |
| ELECTRICAL MACHINERY & SU | 73 | 81 | 90 | 100 | 111 | 123 | 174 | 237 | 322 | 433 | 582 |
| MOTOR VEHICLES & EQUIPMEN | 183 | 149 | 122 | 100 | 82 | 67 | 26 | 33 | 42 | 54 | 69 |
| TRANS. EQUIP., EXCL. MTR. | 76 | 83 | 91 | 100 | 110 | 120 | 155 | 183 | 217 | 260 | 313 |
| OTHER MANUFACTURING | 92 | 95 | 97 | 100 | 103 | 105 | 129 | 156 | 189 | 231 | 283 |
| POPULATION (SERIES C-150) | 93 | 94 | 96 | 100 | 104 | 107 | 125 | 145 | 167 | 187 | 207 |

### SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 96 | 97 | 99 | 100 | 101 | 103 | 110 | 118 | 125 | 133 | 140 |
| FORESTRY & FISHERIES | 94 | 96 | 98 | 100 | 102 | 104 | 114 | 124 | 135 | 146 | 157 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 141 | 161 | 182 | 205 |
| CONTRACT CONSTRUCTION | 88 | 92 | 96 | 100 | 104 | 109 | 133 | 161 | 192 | 227 | 267 |
| MANUFACTURING | 88 | 92 | 96 | 100 | 104 | 108 | 132 | 158 | 188 | 221 | 258 |
| FOOD & KINDRED PRODUCTS | 90 | 93 | 97 | 100 | 103 | 107 | 126 | 146 | 169 | 193 | 220 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 85 | 90 | 95 | 100 | 106 | 111 | 144 | 183 | 230 | 285 | 349 |
| LUMBER PRODUCTS & FURNITU | 90 | 93 | 97 | 100 | 104 | 107 | 126 | 148 | 171 | 197 | 224 |
| PAPER & ALLIED PRODUCTS | 85 | 90 | 95 | 100 | 105 | 111 | 141 | 177 | 220 | 269 | 327 |
| PRINTING & PUBLISHING | 87 | 91 | 95 | 100 | 105 | 110 | 137 | 168 | 204 | 245 | 292 |
| CHEMICALS & ALLIED PRODUC | 86 | 91 | 95 | 100 | 105 | 110 | 138 | 171 | 210 | 254 | 304 |
| PETROLEUM REFINING | 88 | 92 | 96 | 100 | 104 | 108 | 131 | 156 | 185 | 217 | 252 |
| PRIMARY METALS | 94 | 96 | 98 | 100 | 102 | 104 | 113 | 123 | 133 | 143 | 153 |
| FABRICATED METALS & ORDNA | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 141 | 161 | 182 | 204 |
| MACHINERY, EXCLUDING ELEC | 87 | 91 | 96 | 100 | 104 | 109 | 134 | 163 | 196 | 233 | 275 |
| ELECTRICAL MACHINERY & SU | 83 | 88 | 94 | 100 | 106 | 113 | 150 | 196 | 253 | 321 | 403 |
| MOTOR VEHICLES & EQUIPMEN | 88 | 92 | 96 | 100 | 104 | 109 | 134 | 162 | 194 | 231 | 272 |
| TRANS. EQUIP., EXCL. MTR. | 92 | 95 | 97 | 100 | 103 | 105 | 119 | 134 | 150 | 167 | 184 |
| OTHER MANUFACTURING | 86 | 90 | 95 | 100 | 105 | 111 | 141 | 176 | 218 | 266 | 322 |
| POPULATION (SERIES E-0) | 93 | 94 | 96 | 100 | 104 | 107 | 119 | 129 | 139 | 147 | 154 |

TABLE B.3.14

SAN JOAQUIN COUNTY - Stockton SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 94 | 96 | 98 | 100 | 102 | 104 | 106 | 108 | 107 | 113 | 129 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CONTRACT CONSTRUCTION | 92 | 95 | 97 | 100 | 103 | 105 | 126 | 149 | 175 | 211 | 254 |
| MANUFACTURING | 85 | 90 | 95 | 100 | 105 | 111 | 135 | 163 | 197 | 240 | 293 |
| FOOD & KINDRED PRODUCTS | 90 | 93 | 96 | 100 | 104 | 108 | 128 | 151 | 178 | 212 | 252 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 62 | 72 | 85 | 100 | 110 | 138 | 178 | 200 | 242 | 285 | 337 |
| LUMBER PRODUCTS & FURNITU | 79 | 85 | 92 | 100 | 108 | 117 | 145 | 170 | 200 | 236 | 279 |
| PAPER & ALLIED PRODUCTS | 85 | 90 | 95 | 100 | 105 | 111 | 135 | 160 | 188 | 225 | 270 |
| PRINTING & PUBLISHING | 87 | 91 | 96 | 100 | 105 | 110 | 132 | 157 | 185 | 224 | 272 |
| CHEMICALS & ALLIED PRODUC | 74 | 82 | 91 | 100 | 110 | 122 | 172 | 231 | 308 | 410 | 546 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 79 | 85 | 92 | 100 | 108 | 117 | 139 | 161 | 191 | 224 | 264 |
| FABRICATED METALS & ORDNA | 87 | 91 | 96 | 100 | 105 | 109 | 129 | 160 | 199 | 242 | 312 |
| MACHINERY, EXCLUDING ELEC | 87 | 91 | 95 | 100 | 105 | 110 | 125 | 142 | 161 | 187 | 217 |
| ELECTRICAL MACHINERY & SU | 73 | 81 | 90 | 100 | 111 | 124 | 178 | 243 | 328 | 433 | 573 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 74 | 82 | 90 | 100 | 111 | 122 | 161 | 195 | 238 | 294 | 363 |
| OTHER MANUFACTURING | 88 | 92 | 96 | 100 | 105 | 109 | 134 | 164 | 202 | 248 | 305 |
| POPULATION (SERIES C-150) | 98 | 99 | 100 | 100 | 101 | 102 | 113 | 123 | 133 | 143 | 153 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 96 | 97 | 99 | 100 | 101 | 103 | 109 | 116 | 123 | 130 | 136 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CONTRACT CONSTRUCTION | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 142 | 162 | 183 | 206 |
| MANUFACTURING | 89 | 93 | 96 | 100 | 104 | 108 | 128 | 150 | 175 | 203 | 233 |
| FOOD & KINDRED PRODUCTS | 90 | 93 | 96 | 100 | 104 | 107 | 127 | 148 | 172 | 198 | 226 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 89 | 92 | 96 | 100 | 104 | 108 | 130 | 154 | 181 | 211 | 244 |
| LUMBER PRODUCTS & FURNITU | 91 | 94 | 97 | 100 | 103 | 107 | 124 | 143 | 163 | 186 | 209 |
| PAPER & ALLIED PRODUCTS | 90 | 93 | 96 | 100 | 104 | 107 | 127 | 149 | 173 | 200 | 229 |
| PRINTING & PUBLISHING | 89 | 93 | 96 | 100 | 104 | 108 | 128 | 150 | 175 | 202 | 232 |
| CHEMICALS & ALLIED PRODUC | 84 | 89 | 94 | 100 | 106 | 112 | 146 | 188 | 239 | 299 | 370 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 93 | 95 | 98 | 100 | 102 | 105 | 118 | 131 | 145 | 159 | 174 |
| FABRICATED METALS & ORDNA | 94 | 96 | 98 | 100 | 102 | 104 | 114 | 124 | 134 | 145 | 156 |
| MACHINERY, EXCLUDING ELEC | 93 | 95 | 98 | 100 | 102 | 105 | 118 | 131 | 145 | 160 | 175 |
| ELECTRICAL MACHINERY & SU | 84 | 89 | 95 | 100 | 106 | 112 | 145 | 185 | 234 | 291 | 359 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 140 | 160 | 180 | 202 |
| OTHER MANUFACTURING | 87 | 92 | 96 | 100 | 104 | 109 | 134 | 162 | 195 | 231 | 272 |
| POPULATION (SERIES E-0) | 98 | 99 | 100 | 100 | 101 | 102 | 108 | 113 | 117 | 121 | 124 |

TABLE B.3.15

SAN MATEO-ALAMEDA-CONTRA COSTA-MARIN-SAN FRANCISCO COUNTIES - San Francisco-Oakland SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 96 | 97 | 98 | 100 | 102 | 103 | 110 | 115 | 119 | 129 | 140 |
| FORESTRY & FISHERIES | 95 | 96 | 98 | 100 | 102 | 104 | 117 | 136 | 154 | 177 | 202 |
| MINING | | | | | | | | | | | |
| METAL | 85 | 90 | 95 | 100 | 105 | 111 | 142 | 164 | 198 | 235 | 278 |
| CRUDE PETROLEUM & NATURAL | 103 | 102 | 101 | 100 | 99 | 98 | 109 | 123 | 138 | 155 | 175 |
| NONMETALLIC, EXCEPT FUELS | 91 | 94 | 97 | 100 | 103 | 107 | 128 | 145 | 166 | 192 | 222 |
| CONTRACT CONSTRUCTION | 85 | 90 | 95 | 100 | 105 | 111 | 135 | 162 | 196 | 239 | 292 |
| MANUFACTURING | 84 | 89 | 94 | 100 | 106 | 112 | 137 | 163 | 197 | 240 | 292 |
| FOOD & KINDRED PRODUCTS | 90 | 93 | 96 | 100 | 104 | 108 | 122 | 135 | 151 | 170 | 192 |
| TEXTILE MILL PRODUCTS | 102 | 102 | 101 | 100 | 99 | 98 | 113 | 125 | 139 | 157 | 176 |
| APPAREL & OTHER FABRIC PR | 83 | 88 | 94 | 100 | 106 | 113 | 139 | 166 | 198 | 238 | 286 |
| LUMBER PRODUCTS & FURNITU | 72 | 81 | 90 | 100 | 111 | 124 | 149 | 170 | 194 | 224 | 257 |
| PAPER & ALLIED PRODUCTS | 87 | 91 | 95 | 100 | 105 | 110 | 129 | 151 | 176 | 208 | 248 |
| PRINTING & PUBLISHING | 85 | 90 | 95 | 100 | 106 | 112 | 135 | 161 | 191 | 231 | 278 |
| CHEMICALS & ALLIED PRODUC | 83 | 89 | 94 | 100 | 106 | 113 | 139 | 169 | 206 | 253 | 311 |
| PETROLEUM REFINING | 95 | 97 | 98 | 100 | 102 | 103 | 121 | 141 | 163 | 190 | 222 |
| PRIMARY METALS | 86 | 91 | 95 | 100 | 105 | 110 | 123 | 137 | 153 | 172 | 194 |
| FABRICATED METALS & ORDNA | 87 | 91 | 96 | 100 | 105 | 109 | 133 | 163 | 199 | 246 | 304 |
| MACHINERY, EXCLUDING ELEC | 84 | 89 | 94 | 100 | 106 | 112 | 140 | 173 | 214 | 266 | 332 |
| ELECTRICAL MACHINERY & SU | 76 | 83 | 91 | 100 | 110 | 121 | 171 | 228 | 302 | 398 | 524 |
| MOTOR VEHICLES & EQUIPMEN | 63 | 73 | 86 | 100 | 117 | 136 | 185 | 225 | 275 | 339 | 418 |
| TRANS. EQUIP., EXCL. MTR. | 82 | 87 | 93 | 100 | 107 | 115 | 114 | 130 | 148 | 171 | 199 |
| OTHER MANUFACTURING | 88 | 92 | 96 | 100 | 104 | 109 | 134 | 161 | 194 | 237 | 289 |
| POPULATION (SERIES C-150) | 99 | 100 | 100 | 100 | 100 | 100 | 106 | 112 | 119 | 126 | 133 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 121 | 130 | 139 | 149 |
| FORESTRY & FISHERIES | 92 | 95 | 97 | 100 | 103 | 106 | 120 | 136 | 152 | 169 | 187 |
| MINING | | | | | | | | | | | |
| METAL | 99 | 99 | 100 | 100 | 100 | 101 | 102 | 104 | 106 | 107 | 109 |
| CRUDE PETROLEUM & NATURAL | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 141 | 161 | 182 | 204 |
| NONMETALLIC, EXCEPT FUELS | 95 | 96 | 98 | 100 | 102 | 104 | 113 | 122 | 132 | 141 | 151 |
| CONTRACT CONSTRUCTION | 89 | 93 | 96 | 100 | 104 | 108 | 128 | 151 | 177 | 205 | 235 |
| MANUFACTURING | 90 | 93 | 97 | 100 | 103 | 107 | 125 | 145 | 166 | 189 | 214 |
| FOOD & KINDRED PRODUCTS | 94 | 96 | 98 | 100 | 102 | 104 | 114 | 125 | 135 | 146 | 158 |
| TEXTILE MILL PRODUCTS | 98 | 99 | 99 | 100 | 101 | 101 | 104 | 107 | 109 | 112 | 114 |
| APPAREL & OTHER FABRIC PR | 90 | 93 | 97 | 100 | 104 | 107 | 127 | 148 | 172 | 197 | 225 |
| LUMBER PRODUCTS & FURNITU | 93 | 95 | 97 | 100 | 103 | 105 | 118 | 133 | 147 | 163 | 179 |
| PAPER & ALLIED PRODUCTS | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 141 | 160 | 181 | 203 |
| PRINTING & PUBLISHING | 90 | 93 | 96 | 100 | 104 | 107 | 127 | 149 | 173 | 200 | 229 |
| CHEMICALS & ALLIED PRODUC | 88 | 92 | 96 | 100 | 104 | 109 | 132 | 160 | 190 | 225 | 263 |
| PETROLEUM REFINING | 91 | 94 | 97 | 100 | 103 | 107 | 124 | 143 | 163 | 185 | 208 |
| PRIMARY METALS | 96 | 97 | 99 | 100 | 101 | 103 | 110 | 116 | 123 | 130 | 137 |
| FABRICATED METALS & ORDNA | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 141 | 160 | 180 | 202 |
| MACHINERY, EXCLUDING ELEC | 89 | 93 | 96 | 100 | 104 | 107 | 128 | 150 | 175 | 202 | 232 |
| ELECTRICAL MACHINERY & SU | 86 | 90 | 95 | 100 | 105 | 110 | 139 | 174 | 214 | 260 | 313 |
| MOTOR VEHICLES & EQUIPMEN | 90 | 94 | 97 | 100 | 103 | 107 | 124 | 144 | 165 | 187 | 212 |
| TRANS. EQUIP., EXCL. MTR. | 94 | 96 | 98 | 100 | 102 | 104 | 113 | 123 | 133 | 143 | 154 |
| OTHER MANUFACTURING | 89 | 93 | 96 | 100 | 104 | 108 | 129 | 152 | 179 | 207 | 239 |
| POPULATION (SERIES E-0) | 99 | 100 | 100 | 100 | 100 | 100 | 103 | 105 | 108 | 109 | 110 |

TABLE B.3.16

SANTA BARBARA COUNTY - Santa Barbara-Lompoc-Santa Maria SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 102 | 101 | 101 | 100 | 99 | 99 | 89 | 82 | 77 | 83 | 90 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 85 | 90 | 95 | 100 | 105 | 111 | 170 | 232 | 297 | 385 | 493 |
| CRUDE PETROLEUM & NATURAL | 98 | 99 | 99 | 100 | 101 | 101 | 98 | 107 | 117 | 127 | 139 |
| NONMETALLIC, EXCEPT FUELS | 88 | 92 | 96 | 100 | 104 | 109 | 127 | 146 | 156 | 177 | 201 |
| CONTRACT CONSTRUCTION | 76 | 83 | 91 | 100 | 110 | 130 | 154 | 195 | 248 | 316 | 403 |
| MANUFACTURING | 87 | 91 | 95 | 100 | 105 | 110 | 131 | 158 | 191 | 232 | 283 |
| FOOD & KINDRED PRODUCTS | 96 | 97 | 99 | 100 | 101 | 103 | 114 | 119 | 125 | 133 | 141 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| LUMBER PRODUCTS & FURNITU | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PAPER & ALLIED PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRINTING & PUBLISHING | 94 | 96 | 98 | 100 | 102 | 104 | 122 | 146 | 171 | 205 | 247 |
| CHEMICALS & ALLIED PRODUC | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 109 | 119 | 129 | 138 | 148 |
| PRIMARY METALS | 95 | 97 | 98 | 100 | 102 | 104 | 85 | 91 | 99 | 109 | 120 |
| FABRICATED METALS & ORDNA | 79 | 85 | 92 | 100 | 108 | 117 | 148 | 185 | 231 | 290 | 364 |
| MACHINERY, EXCLUDING ELEC | 92 | 94 | 97 | 100 | 103 | 106 | 121 | 139 | 159 | 186 | 217 |
| ELECTRICAL MACHINERY & SU | 97 | 98 | 99 | 100 | 101 | 102 | 119 | 143 | 170 | 204 | 244 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 62 | 73 | 85 | 100 | 117 | 137 | 129 | 163 | 205 | 257 | 322 |
| OTHER MANUFACTURING | 85 | 90 | 95 | 100 | 105 | 111 | 133 | 175 | 215 | 266 | 330 |
| POPULATION (SERIES C-150) | 97 | 98 | 99 | 100 | 102 | 102 | 113 | 124 | 137 | 149 | 161 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 97 | 98 | 99 | 100 | 101 | 102 | 107 | 112 | 117 | 122 | 127 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 97 | 98 | 99 | 100 | 101 | 102 | 106 | 110 | 115 | 119 | 123 |
| NONMETALLIC, EXCEPT FUELS | 96 | 97 | 99 | 100 | 101 | 103 | 109 | 116 | 122 | 129 | 135 |
| CONTRACT CONSTRUCTION | 88 | 92 | 96 | 100 | 104 | 109 | 134 | 162 | 194 | 230 | 270 |
| MANUFACTURING | 91 | 94 | 97 | 100 | 103 | 106 | 122 | 139 | 157 | 177 | 197 |
| FOOD & KINDRED PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 99 | 99 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| LUMBER PRODUCTS & FURNITU | 95 | 97 | 98 | 100 | 102 | 103 | 111 | 119 | 128 | 136 | 144 |
| PAPER & ALLIED PRODUCTS | 86 | 90 | 95 | 100 | 105 | 111 | 140 | 176 | 217 | 265 | 321 |
| PRINTING & PUBLISHING | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 140 | 160 | 180 | 202 |
| CHEMICALS & ALLIED PRODUC | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PETROLEUM REFINING | 95 | 97 | 98 | 100 | 102 | 103 | 111 | 118 | 126 | 134 | 141 |
| PRIMARY METALS | 97 | 98 | 99 | 100 | 101 | 102 | 106 | 110 | 114 | 118 | 122 |
| FABRICATED METALS & ORDNA | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 141 | 160 | 180 | 202 |
| MACHINERY, EXCLUDING ELEC | 93 | 96 | 98 | 100 | 102 | 104 | 116 | 128 | 140 | 153 | 166 |
| ELECTRICAL MACHINERY & SU | 93 | 95 | 98 | 100 | 102 | 105 | 118 | 132 | 146 | 161 | 177 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 141 | 160 | 181 | 203 |
| OTHER MANUFACTURING | 88 | 92 | 96 | 100 | 104 | 109 | 132 | 159 | 189 | 222 | 259 |
| POPULATION (SERIES E-0) | 97 | 98 | 99 | 100 | 102 | 102 | 109 | 114 | 119 | 123 | 126 |

TABLE B.3.17

SANTA CLARA COUNTY - San Jose SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 91 | 94 | 97 | 100 | 103 | 106 | 111 | 116 | 121 | 131 | 142 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 82 | 88 | 94 | 100 | 107 | 114 | 150 | 168 | 195 | 224 | 257 |
| CONTRACT CONSTRUCTION | 80 | 86 | 93 | 100 | 108 | 116 | 148 | 188 | 238 | 303 | 386 |
| MANUFACTURING | 80 | 86 | 93 | 100 | 108 | 116 | 153 | 198 | 257 | 333 | 432 |
| FOOD & KINDRED PRODUCTS | 82 | 88 | 94 | 100 | 107 | 114 | 135 | 157 | 183 | 213 | 249 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 81 | 87 | 93 | 100 | 107 | 115 | 154 | 191 | 236 | 291 | 359 |
| LUMBER PRODUCTS & FURNITU | 76 | 83 | 91 | 100 | 110 | 120 | 142 | 161 | 183 | 208 | 238 |
| PAPER & ALLIED PRODUCTS | 85 | 90 | 95 | 100 | 106 | 112 | 141 | 173 | 213 | 263 | 325 |
| PRINTING & PUBLISHING | 88 | 92 | 96 | 100 | 104 | 109 | 142 | 180 | 226 | 285 | 360 |
| CHEMICALS & ALLIED PRODUC | 77 | 84 | 92 | 100 | 109 | 119 | 157 | 205 | 268 | 348 | 453 |
| PETROLEUM REFINING | 91 | 94 | 97 | 100 | 103 | 107 | 143 | 171 | 209 | 260 | 323 |
| PRIMARY METALS | 76 | 83 | 91 | 100 | 110 | 120 | 136 | 155 | 175 | 200 | 228 |
| FABRICATED METALS & ORDNA | 77 | 84 | 92 | 100 | 109 | 119 | 153 | 191 | 239 | 300 | 377 |
| MACHINERY, EXCLUDING ELEC | 87 | 91 | 95 | 100 | 105 | 110 | 144 | 186 | 239 | 309 | 400 |
| ELECTRICAL MACHINERY & SU | 80 | 86 | 93 | 100 | 108 | 116 | 162 | 220 | 299 | 402 | 540 |
| MOTOR VEHICLES & EQUIPMEN | 62 | 72 | 85 | 100 | 118 | 138 | 188 | 229 | 279 | 344 | 425 |
| TRANS. EQUIP., EXCL. MTR. | 109 | 106 | 103 | 100 | 97 | 94 | 77 | 93 | 113 | 137 | 166 |
| OTHER MANUFACTURING | 87 | 91 | 96 | 100 | 105 | 110 | 138 | 169 | 208 | 258 | 320 |
| POPULATION (SERIES C-150) | 94 | 95 | 98 | 100 | 102 | 104 | 118 | 132 | 146 | 158 | 169 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 121 | 130 | 139 | 149 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CONTRACT CONSTRUCTION | 86 | 91 | 95 | 100 | 105 | 110 | 137 | 170 | 207 | 249 | 298 |
| MANUFACTURING | 87 | 91 | 96 | 100 | 105 | 109 | 136 | 166 | 201 | 240 | 285 |
| FOOD & KINDRED PRODUCTS | 92 | 94 | 97 | 100 | 103 | 106 | 121 | 137 | 155 | 173 | 193 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 89 | 92 | 96 | 100 | 104 | 109 | 132 | 159 | 189 | 223 | 261 |
| LUMBER PRODUCTS & FURNITU | 93 | 95 | 98 | 100 | 102 | 105 | 117 | 129 | 142 | 156 | 170 |
| PAPER & ALLIED PRODUCTS | 88 | 92 | 96 | 100 | 104 | 108 | 131 | 157 | 186 | 219 | 255 |
| PRINTING & PUBLISHING | 87 | 91 | 95 | 100 | 105 | 110 | 137 | 169 | 206 | 248 | 295 |
| CHEMICALS & ALLIED PRODUC | 84 | 89 | 95 | 100 | 106 | 112 | 145 | 186 | 234 | 292 | 359 |
| PETROLEUM REFINING | 87 | 91 | 96 | 100 | 105 | 109 | 135 | 166 | 200 | 239 | 284 |
| PRIMARY METALS | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 121 | 129 | 138 | 147 |
| FABRICATED METALS & ORDNA | 90 | 93 | 97 | 100 | 104 | 107 | 126 | 147 | 170 | 195 | 223 |
| MACHINERY, EXCLUDING ELEC | 87 | 91 | 96 | 100 | 105 | 109 | 136 | 165 | 201 | 241 | 286 |
| ELECTRICAL MACHINERY & SU | 85 | 90 | 95 | 100 | 106 | 111 | 144 | 183 | 230 | 286 | 351 |
| MOTOR VEHICLES & EQUIPMEN | 90 | 94 | 97 | 100 | 103 | 107 | 124 | 144 | 165 | 188 | 212 |
| TRANS. EQUIP., EXCL. MTR. | 91 | 94 | 97 | 100 | 103 | 106 | 122 | 140 | 158 | 178 | 199 |
| OTHER MANUFACTURING | 88 | 92 | 96 | 100 | 104 | 109 | 133 | 161 | 193 | 229 | 269 |
| POPULATION (SERIES E-0) | 94 | 95 | 98 | 100 | 102 | 104 | 114 | 122 | 129 | 135 | 139 |

TABLE B.3.18

SANTA CRUZ COUNTY - Santa Cruz SMSA

SERIES '[illegible]' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 97 | 98 | 99 | 100 | 101 | 102 | 100 | 102 | 103 | 112 | 123 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 92 | 95 | 97 | 100 | 103 | [illegible] | 126 | 145 | [illegible] | [illegible] | [illegible] |
| CONTRACT CONSTRUCTION | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MANUFACTURING | 81 | 87 | 93 | 100 | 107 | 115 | 152 | 187 | [illegible] | 284 | [illegible] |
| FOOD & KINDRED PRODUCTS | 90 | 93 | 97 | 100 | 104 | 107 | 133 | 155 | 179 | [illegible] | [illegible] |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| LUMBER PRODUCTS & FURNITU | 71 | 79 | 89 | 100 | 112 | 136 | 157 | 189 | 224 | 277 | 336 |
| PAPER & ALLIED PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRINTING & PUBLISHING | 81 | 87 | 93 | 100 | 107 | 115 | 161 | 209 | 280 | 371 | 493 |
| CHEMICALS & ALLIED PRODUC | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 78 | 85 | 92 | 100 | 109 | 118 | 149 | 180 | 219 | 264 | 317 |
| FABRICATED METALS & ORDNA | 101 | 100 | 100 | 100 | 100 | 100 | 124 | 142 | [illegible] | [illegible] | 217 |
| MACHINERY, EXCLUDING ELEC | 71 | 79 | 89 | 100 | 112 | 136 | 200 | 274 | 378 | 510 | 6[illegible]9 |
| ELECTRICAL MACHINERY & SU | 59 | 70 | 83 | 100 | 120 | 144 | 256 | 301 | 400 | 520 | 6[illegible]3 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| OTHER MANUFACTURING | 92 | 95 | 97 | 100 | 103 | 105 | 136 | 173 | 219 | 277 | 351 |
| POPULATION (SERIES C-150) | 88 | 91 | 97 | 100 | 103 | 105 | 127 | 149 | 171 | 192 | 214 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 121 | 130 | 139 | 148 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | .100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 95 | 96 | 98 | .100 | 102 | 104 | 113 | 122 | 131 | 141 | 151 |
| CONTRACT CONSTRUCTION | 88 | 92 | 96 | 100 | 104 | 109 | 132 | 159 | 189 | 223 | 260 |
| MANUFACTURING | 89 | 92 | 96 | 100 | 104 | 108 | 130 | 156 | 184 | 215 | 249 |
| FOOD & KINDRED PRODUCTS | 92 | 94 | 97 | 100 | 103 | 106 | 121 | 136 | 153 | 171 | 190 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| LUMBER PRODUCTS & FURNITU | 89 | 93 | 96 | 100 | 104 | 108 | 128 | 151 | 176 | 204 | 234 |
| PAPER & ALLIED PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 103 | 100 |
| PRINTING & PUBLISHING | 83 | 88 | 94 | 100 | 102 | 113 | 150 | 196 | 252 | 329 | 401 |
| CHEMICALS & ALLIED PRODUC | 100 | 100 | 100 | 100 | 100 | 109 | 100 | 100 | 100 | 100 | 100 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 109 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 91 | 94 | 97 | 100 | 103 | 106 | 122 | 140 | 159 | [illegible] | 200 |
| FABRICATED METALS & ORDNA | 96 | 97 | 99 | 100 | 101 | 103 | 110 | 117 | 134 | 137 | 139 |
| MACHINERY, EXCLUDING ELEC | 84 | 89 | 94 | 100 | 106 | 112 | 137 | 189 | 239 | 308 | 373 |
| ELECTRICAL MACHINERY & SU | 80 | 90 | 95 | 100 | 105 | 110 | 140 | 175 | 215 | [illegible] | 217 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| OTHER MANUFACTURING | 86 | 91 | 95 | 100 | 105 | .110 | 137 | 169 | 206 | 249 | [illegible] |
| POPULATION (SERIES E-[illegible]) | 88 | 91 | 97 | 100 | 103 | 105 | 121 | 123 | [illegible] | [illegible] | 140 |

TABLE B.3.19

SONOMA COUNTY - Santa Rosa SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 107 | 104 | 102 | 100 | 98 | 96 | 83 | 87 | 90 | 98 | 107 |
| FORESTRY & FISHERIES | 88 | 92 | 96 | 100 | 104 | 108 | 139 | 170 | 201 | 230 | 263 |
| MINING | | | | | | | | | | | |
| METAL | 84 | 89 | 94 | 100 | 106 | 112 | 118 | 139 | 163 | 191 | 225 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 85 | 90 | 95 | 100 | 105 | 111 | 137 | 155 | 177 | 205 | 237 |
| CONTRACT CONSTRUCTION | 85 | 89 | 95 | 100 | 106 | 112 | 136 | 168 | 207 | 258 | 321 |
| MANUFACTURING | 84 | 89 | 94 | 100 | 106 | 112 | 137 | 163 | 196 | 240 | 292 |
| FOOD & KINDRED PRODUCTS | 94 | 96 | 98 | 100 | 102 | 104 | 114 | 123 | 133 | 147 | 161 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| LUMBER PRODUCTS & FURNITU | 73 | 81 | 90 | 100 | 111 | 124 | 145 | 175 | 206 | 243 | 286 |
| PAPER & ALLIED PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRINTING & PUBLISHING | 86 | 90 | 95 | 100 | 105 | 111 | 136 | 164 | 200 | 245 | 300 |
| CHEMICALS & ALLIED PRODUC | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 65 | 75 | 87 | 100 | 115 | 133 | 162 | 190 | 223 | 260 | 304 |
| FABRICATED METALS & ORDNA | 81 | 87 | 93 | 100 | 107 | 115 | 146 | 180 | 223 | 279 | 348 |
| MACHINERY, EXCLUDING ELEC | 89 | 92 | 96 | 100 | 104 | 108 | 121 | 154 | 193 | 246 | 314 |
| ELECTRICAL MACHINERY & SU | 102 | 101 | 101 | 100 | 99 | 99 | 143 | 210 | 309 | 439 | 624 |
| MOTOR VEHICLES & EQUIPMEN | 78 | 85 | 92 | 100 | 109 | 118 | 154 | 190 | 237 | 290 | 355 |
| TRANS. EQUIP., EXCL. MTR. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| OTHER MANUFACTURING | 83 | 88 | 94 | 100 | 107 | 114 | 152 | 192 | 241 | 305 | 386 |
| POPULATION (SERIES C-150) | 89 | 91 | 96 | 100 | 103 | 105 | 131 | 159 | 186 | 214 | 244 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 121 | 130 | 140 | 149 |
| FORESTRY & FISHERIES | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 142 | 161 | 182 | 205 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 95 | 96 | 98 | 100 | 102 | 104 | 113 | 122 | 132 | 142 | 152 |
| CONTRACT CONSTRUCTION | 88 | 92 | 96 | 100 | 104 | 109 | 132 | 160 | 190 | 224 | 263 |
| MANUFACTURING | 90 | 93 | 96 | 100 | 104 | 107 | 127 | 149 | 173 | 199 | 228 |
| FOOD & KINDRED PRODUCTS | 96 | 97 | 99 | 100 | 101 | 103 | 109 | 116 | 122 | 128 | 135 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| LUMBER PRODUCTS & FURNITU | 91 | 94 | 97 | 100 | 103 | 106 | 123 | 142 | 162 | 183 | 206 |
| PAPER & ALLIED PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRINTING & PUBLISHING | 89 | 92 | 96 | 100 | 104 | 108 | 130 | 155 | 183 | 214 | 248 |
| CHEMICALS & ALLIED PRODUC | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| FABRICATED METALS & ORDNA | 90 | 93 | 97 | 100 | 103 | 107 | 126 | 146 | 169 | 193 | 220 |
| MACHINERY, EXCLUDING ELEC | 88 | 92 | 96 | 100 | 104 | 109 | 132 | 159 | 190 | 224 | 261 |
| ELECTRICAL MACHINERY & SU | 81 | 87 | 93 | 100 | 107 | 114 | 157 | 212 | 282 | 365 | 474 |
| MOTOR VEHICLES & EQUIPMEN | 90 | 93 | 97 | 100 | 103 | 107 | 126 | 146 | 169 | 194 | 220 |
| TRANS. EQUIP., EXCL. MTR. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| OTHER MANUFACTURING | 86 | 91 | 95 | 100 | 105 | 110 | 137 | 170 | 207 | 250 | 299 |
| POPULATION (SERIES E-0) | 89 | 91 | 96 | 100 | 103 | 105 | 124 | 136 | 145 | 154 | 162 |

TABLE B.3.20

STANISLAUS COUNTY - Modesto SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 94 | 96 | 98 | 100 | 102 | 104 | 102 | 107 | 111 | 121 | 131 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CONTRACT CONSTRUCTION | 86 | 90 | 95 | 100 | 105 | 111 | 134 | 164 | 201 | 250 | 310 |
| MANUFACTURING | 88 | 92 | 96 | 100 | 104 | 109 | 134 | 164 | 202 | 250 | 310 |
| FOOD & KINDRED PRODUCTS | 94 | 96 | 98 | 100 | 102 | 104 | 122 | 144 | 169 | 201 | 238 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| LUMBER PRODUCTS & FURNITU | 99 | 99 | 100 | 100 | 100 | 101 | 113 | 132 | 156 | 185 | 219 |
| PAPER & ALLIED PRODUCTS | 88 | 92 | 96 | 100 | 104 | 109 | 136 | 166 | 203 | 251 | 309 |
| PRINTING & PUBLISHING | 89 | 92 | 96 | 100 | 104 | 108 | 135 | 168 | 209 | 263 | 332 |
| CHEMICALS & ALLIED PRODUC | 87 | 91 | 95 | 100 | 105 | 110 | 140 | 180 | 230 | 296 | 379 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| FABRICATED METALS & ORDNA | 61 | 72 | 85 | 100 | 118 | 138 | 196 | 261 | 348 | 464 | 619 |
| MACHINERY, EXCLUDING ELEC | 90 | 93 | 97 | 100 | 104 | 107 | 115 | 132 | 145 | 163 | 184 |
| ELECTRICAL MACHINERY & SU | 85 | 89 | 95 | 100 | 106 | 112 | 152 | 206 | 279 | 366 | 481 |
| MOTOR VEHICLES & EQUIPMEN | 78 | 85 | 92 | 100 | 109 | 118 | 163 | 192 | 237 | 290 | 355 |
| TRANS. EQUIP., EXCL. MTR. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| OTHER MANUFACTURING | 90 | 93 | 97 | 100 | 104 | 107 | 150 | 197 | 259 | 343 | 453 |
| POPULATION (SERIES C-150) | 96 | 97 | 98 | 100 | 102 | 104 | 117 | 131 | 144 | 156 | 168 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 96 | 97 | 99 | 100 | 101 | 103 | 110 | 118 | 126 | 133 | 141 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NONMETALLIC, EXCEPT FUELS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CONTRACT CONSTRUCTION | 88 | 92 | 96 | 100 | 104 | 108 | 131 | 156 | 184 | 215 | 250 |
| MANUFACTURING | 88 | 92 | 96 | 100 | 104 | 108 | 131 | 156 | 185 | 217 | 252 |
| FOOD & KINDRED PRODUCTS | 90 | 93 | 97 | 100 | 104 | 107 | 126 | 147 | 170 | 195 | 222 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| LUMBER PRODUCTS & FURNITU | 90 | 93 | 97 | 100 | 103 | 107 | 128 | 145 | 166 | 190 | 215 |
| PAPER & ALLIED PRODUCTS | 88 | 92 | 96 | 100 | 104 | 109 | 133 | 161 | 193 | 229 | 269 |
| PRINTING & PUBLISHING | 87 | 91 | 95 | 100 | 105 | 110 | 137 | 168 | 204 | 245 | 292 |
| CHEMICALS & ALLIED PRODUC | 86 | 91 | 95 | 100 | 105 | 110 | 137 | 169 | 207 | 249 | 298 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| FABRICATED METALS & ORDNA | 90 | 93 | 97 | 100 | 103 | 107 | 126 | 147 | 169 | 194 | 221 |
| MACHINERY, EXCLUDING ELEC | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 121 | 130 | 139 | 149 |
| ELECTRICAL MACHINERY & SU | 84 | 89 | 94 | 100 | 106 | 113 | 146 | 187 | 237 | 296 | 365 |
| MOTOR VEHICLES & EQUIPMEN | 91 | 94 | 97 | 100 | 103 | 107 | 124 | 143 | 164 | 186 | 210 |
| TRANS. EQUIP., EXCL. MTR. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| OTHER MANUFACTURING | 82 | 88 | 94 | 100 | 107 | 113 | 153 | 204 | 266 | 343 | 435 |
| POPULATION (SERIES E-0) | 96 | 97 | 98 | 100 | 102 | 104 | 111 | 116 | 121 | 126 | 129 |

TABLE B.3.21

VENTURA COUNTY - Oxnard - Simi Valley-Ventura SMSA

SERIES 'C' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 87 | 91 | 96 | 100 | 105 | 109 | 118 | 124 | 130 | 141 | 153 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 95 | 97 | 98 | 100 | 102 | 103 | 115 | 125 | 137 | 149 | 163 |
| NONMETALLIC, EXCEPT FUELS | 85 | 90 | 95 | 100 | 106 | 111 | 130 | 152 | 181 | 215 | 254 |
| CONTRACT CONSTRUCTION | 89 | 92 | 96 | 100 | 104 | 108 | 126 | 163 | 212 | 274 | 355 |
| MANUFACTURING | 77 | 84 | 92 | 100 | 109 | 119 | 165 | 211 | 270 | 344 | 438 |
| FOOD & KINDRED PRODUCTS | 83 | 88 | 94 | 100 | 106 | 113 | 157 | 193 | 238 | 290 | 355 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 73 | 81 | 90 | 100 | 111 | 123 | 192 | 254 | 336 | 435 | 564 |
| LUMBER PRODUCTS & FURNITU | 72 | 81 | 90 | 100 | 111 | 124 | 178 | 223 | 280 | 351 | 440 |
| PAPER & ALLIED PRODUCTS | 155 | 134 | 116 | 100 | 86 | 75 | 92 | 124 | 166 | 219 | 287 |
| PRINTING & PUBLISHING | 83 | 89 | 94 | 100 | 106 | 113 | 154 | 197 | 255 | 328 | 421 |
| CHEMICALS & ALLIED PRODUC | 77 | 84 | 92 | 100 | 109 | 119 | 177 | 242 | 328 | 441 | 592 |
| PETROLEUM REFINING | 85 | 90 | 95 | 100 | 105 | 111 | 132 | 157 | 189 | 226 | 271 |
| PRIMARY METALS | 79 | 86 | 93 | 100 | 108 | 117 | 135 | 161 | 193 | 229 | 272 |
| FABRICATED METALS & ORDNA | 76 | 83 | 91 | 100 | 110 | 120 | 158 | 201 | 258 | 331 | 424 |
| MACHINERY, EXCLUDING ELEC | 79 | 85 | 92 | 100 | 108 | 117 | 179 | 247 | 339 | 452 | 602 |
| ELECTRICAL MACHINERY & SU | 72 | 80 | 90 | 100 | 112 | 125 | 177 | 232 | 304 | 395 | 514 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 63 | 73 | 86 | 100 | 117 | 136 | 192 | 235 | 287 | 352 | 432 |
| OTHER MANUFACTURING | 93 | 96 | 98 | 100 | 102 | 105 | 146 | 191 | 250 | 327 | 426 |
| POPULATION (SERIES C-150) | 92 | 94 | 97 | 100 | 103 | 106 | 128 | 154 | 181 | 209 | 237 |

SERIES 'E' GROWTH INDICES

(NORMALIZED TO 1973)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGRICULTURE | 95 | 97 | 98 | 100 | 102 | 103 | 112 | 121 | 130 | 140 | 149 |
| FORESTRY & FISHERIES | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MINING | | | | | | | | | | | |
| METAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| CRUDE PETROLEUM & NATURAL | 97 | 98 | 99 | 100 | 101 | 102 | 106 | 111 | 115 | 120 | 124 |
| NONMETALLIC, EXCEPT FUELS | 93 | 95 | 98 | 100 | 102 | 105 | 117 | 130 | 144 | 158 | 173 |
| CONTRACT CONSTRUCTION | 87 | 91 | 95 | 100 | 105 | 110 | 137 | 168 | 204 | 246 | 293 |
| MANUFACTURING | 87 | 91 | 96 | 100 | 105 | 109 | 135 | 164 | 198 | 236 | 279 |
| FOOD & KINDRED PRODUCTS | 90 | 93 | 97 | 100 | 104 | 107 | 126 | 147 | 170 | 195 | 222 |
| TEXTILE MILL PRODUCTS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| APPAREL & OTHER FABRIC PR | 84 | 89 | 94 | 100 | 106 | 112 | 148 | 191 | 244 | 307 | 383 |
| LUMBER PRODUCTS & FURNITU | 86 | 91 | 95 | 100 | 105 | 110 | 138 | 171 | 209 | 254 | 304 |
| PAPER & ALLIED PRODUCTS | 84 | 89 | 94 | 100 | 106 | 112 | 147 | 190 | 242 | 304 | 377 |
| PRINTING & PUBLISHING | 86 | 91 | 95 | 100 | 105 | 110 | 138 | 171 | 209 | 252 | 302 |
| CHEMICALS & ALLIED PRODUC | 83 | 89 | 94 | 100 | 106 | 112 | 149 | 194 | 248 | 314 | 392 |
| PETROLEUM REFINING | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| PRIMARY METALS | 93 | 95 | 98 | 100 | 103 | 105 | 118 | 132 | 146 | 162 | 177 |
| FABRICATED METALS & ORDNA | 90 | 93 | 96 | 100 | 104 | 107 | 127 | 148 | 172 | 198 | 226 |
| MACHINERY, EXCLUDING ELEC | 85 | 89 | 95 | 100 | 106 | 111 | 144 | 184 | 231 | 287 | 352 |
| ELECTRICAL MACHINERY & SU | 87 | 91 | 95 | 100 | 105 | 110 | 136 | 167 | 203 | 244 | 290 |
| MOTOR VEHICLES & EQUIPMEN | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| TRANS. EQUIP., EXCL. MTR. | 93 | 95 | 98 | 100 | 102 | 105 | 118 | 131 | 145 | 160 | 175 |
| OTHER MANUFACTURING | 85 | 90 | 95 | 100 | 105 | 111 | 143 | 182 | 227 | 281 | 344 |
| POPULATION (SERIES E-0) | 92 | 94 | 97 | 100 | 103 | 106 | 120 | 133 | 145 | 155 | 163 |

TABLE B.3.22

EXPLANATORY NOTES FOR TABLES B.3.5 THROUGH B.3.21

Tables B.3.5 through B.3.21 are used to project stationary source emissions. The Series C and E projections are described in Section 3.1.7 of the text. The indices presented in Tables B.3.5 - B.3.21 were developed through computer programs utilizing data from references [37] and [49]. Table B.3.23 depicts an example of using the indices from Table B.3.9 to generate growth factors for Orange County. The Emission Source Categories in Table B.3.23 correspond to emission inventory categories used by the ARB. The Growth Indicator Category Indices correspond to the relationships described by Table 3.11 in the text. For example, it is assumed the Mineral Emissions Category will grow at the rate indicated by the "Mining Non-metallic, except fuels" growth index. From Table B.3.9, the "Mining Non-metallic, except fuels" growth indices for Series C and Series E are:

Orange County Growth Indices

| Mining Non-metallic, except fuels | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1973 | 1974 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 |
| Series C | 100 | 97 | 93 | 119 | 140 | 164 | 196 | 233 |
| Series E | 100 | 102 | 105 | 118 | 131 | 145 | 159 | 174 |

These indices and the other appropriate indices are presented in Table B.3.23. Some time should be spent understanding the relationships between Table 3.11 of the text, Table B.3.9 of Appendix B and Table B.3.23

Study of Tables 3.11, B.3.9 and B.3.23, will reveal that only about one-third of the indices in Table B.3.9 are used in Table B.3.23. The explanation is that Table 3.11 relates only the present form of ARB emission inventory to the industry growth indices in Table B.3.5 through

B.3.21. If an available emissions inventory has greater disaggregation of emission sources, then it may be appropriate to use growth indices different to those described in Table 3.11. Table 3.12 in the text relates the industrial groupings used by OBERS to Standard Industrial Classification (SIC) codes. SIC code descriptions are presented in the Standard Industrial Classification Manual - 1972, prepared by the Office of Management and Budget and available through the U. S. Government Printing Office, Washington, D. C. (Stock number 4101-0066).

The population indices in Tables B.3.5 through B.3.21 are based on either C-150 or E-0 population projections from Department of Finance Report 74 P-2, June 1974. If a range of emission values is desired, then the use of the Series C and Series E indices for population and industry is appropriate to establish the upper and lower limits. However, if only one projection is desired, the D-100 population projection used with the Series E projection for industry is recommended. Discussion with Department of Finance staff indicates that present population trends are best described by the D-100 series.[1] The Series E industry projections are recommended because present economic trends indicate slow growth.

The remainder of this explanatory note lists specific growth indices development by computer program methods.

## Methods Used to Develop Growth Indices

Growth indices of population for both C-150 and E-0 series were obtained from mid-year (July 1) population estimates by county in 1970, 1971, 1972, 1973, 1974, and 1975, and mid-year (July 1) population projections (of the C-150 and E-0 series) for 1980, 1985, 1990, 1995, and 2000. County populations for each year were totaled to produce SMSA population values for the eleven years. All SMSA populations values were then divided by the 1973 SMSA population and multiplied by 100 to produce population growth indices expressed as percentages of the 1973 population (1973 = 100%).

---

[1]Staff discussion with Nels Rasmussen of the Dept. of Finance, March 1976.

Industrial growth indices for the 'C' series were obtained from OBERS industrial earnings data for 1970, 1975, 1980, 1985, 1990, and 2000 [37]. These earnings (expressed in 1967 dollars) were converted to constant dollar gross production using multiples supplied by OBERS. Production for 1971, 1972, 1973, and 1974 was determined from logarithmic interpolation between the 1970 and 1975 production values. Production for 1995 was determined from logarithmic interpolation between 1990 and 2000 production. Production figures for all eleven years were then divided by the 1973 production figure and multiplied by 100 to produce growth indices expressed as percentages of the 1973 activity (1973 = 100%). If the earning data were deleted for reasons of confidentiality, the OBERS indices were used to estimate our growth indices. If a category's earnings were zero or too small to project, all indices were set to 100 to indicate no change in activity.

Industrial growth indices for the 'E' series were obtained from OBERS industrial earnings for 1980, 1985, 1990, 2000, and 2020 [49]. These earnings (expressed in 1967 dollars) were converted to constant dollar gross production using multiples supplied by OBERS. Power curve ($Y=aX^b$) regression was applied to the five production values and the resultant coefficients used to estimate production for all eleven years, based on the growth trend for that category. Production figures for all years were then divided by the 1973 production value and multiplied by 100 to produce growth indices expressed as percentages of the 1973 activity (1973 = 100%). If a category's earnings were too small to project, all indices were set to 100 to indicate no change in activity.

TABLE B.3.23

GROWTH FACTORS FOR STATIONARY SOURCE EMISSIONS

ORANGE COUNTY - Anaheim - Santa Ana - Garden Grove SMSA

| EMISSION SOURCES (Growth Indices Category) | GROWTH FACTORS[1] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1973 | | 1974 | | 1975 | | 1980 | | 1985 | | 1990 | | 1995 | | 2000 | |
| | 'C' | 'E' | 'C' | 'E' | 'C' | 'E' | 'C' | 'E' | 'C' | 'E' | 'C' | 'E' | 'C' | 'E' | 'C' | 'E' |
| PETROLEUM | | | | | | | | | | | | | | | | |
| Production-(Mining-crude petroleum & natural gas) | 100 | 100 | 104 | 101 | 107 | 102 | 118 | 106 | 128 | 111 | 140 | 115 | 153 | 120 | 167 | 124 |
| Refining-(Manufacturing-petroleum refining) | 100 | 100 | 106 | 104 | 113 | 108 | 140 | 129 | 169 | 152 | 203 | 178 | 244 | 207 | 294 | 238 |
| Marketing-(Population) | 100 | 100 | 104 | 104 | 106 | 106 | 125 | 119 | 146 | 130 | 165 | 138 | 180 | 144 | 193 | 149 |
| ORGANIC SOLVENT USERS | | | | | | | | | | | | | | | | |
| Surface Coating-(Manufacturing-composite index) | 100 | 100 | 108 | 104 | 117 | 109 | 157 | 132 | 199 | 158 | 254 | 188 | 324 | 222 | 412 | 259 |
| Dry Cleaning-(Population) | 100 | 100 | 104 | 104 | 106 | 106 | 125 | 119 | 146 | 130 | 165 | 138 | 180 | 144 | 193 | 149 |
| Degreasing-(Manufacturing-composite index) | 100 | 100 | 108 | 104 | 117 | 109 | 157 | 132 | 199 | 158 | 254 | 188 | 324 | 222 | 412 | 259 |
| Other-(Population) | 100 | 100 | 104 | 104 | 106 | 106 | 125 | 119 | 146 | 130 | 165 | 138 | 180 | 144 | 193 | 149 |
| CHEMICAL-(Manufacturing-chemical and allied products) | 100 | 100 | 107 | 106 | 114 | 112 | 168 | 147 | 226 | 191 | 304 | 243 | 405 | 305 | 541 | 379 |
| METALLURGICAL-(Manufacturing-primary metals) | 100 | 100 | 107 | 102 | 114 | 104 | 125 | 115 | 146 | 126 | 170 | 137 | 198 | 149 | 231 | 161 |
| MINERAL-(Mining or non-metallic, except fuels) | 100 | 100 | 97 | 102 | 93 | 105 | 119 | 118 | 140 | 131 | 164 | 145 | 196 | 159 | 233 | 174 |
| FOOD & AGRICULTURAL PROCESSING - (Manufacturing food & kindred products) | 100 | 100 | 105 | 103 | 110 | 106 | 139 | 122 | 167 | 140 | 200 | 159 | 240 | 179 | 288 | 200 |
| PESTICIDES-(Agriculture) | 100 | 100 | 102 | 102 | 103 | 103 | 107 | 112 | 113 | 121 | 118 | 130 | 128 | 140 | 139 | 149 |
| WOOD PROCESSING-(Manufacturing-lumber products & furniture) | 100 | 100 | 111 | 104 | 123 | 108 | 158 | 132 | 192 | 158 | 235 | 188 | 286 | 221 | 348 | 258 |
| COMBUSTION OF FUELS | | | | | | | | | | | | | | | | |
| Power Plants[2] | 100 | 100 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Other Industrial-(Manufacturing-composite index) | 100 | 100 | 108 | 104 | 117 | 109 | 157 | 132 | 199 | 158 | 254 | 188 | 324 | 222 | 412 | 259 |
| Domestic & Commerical-(Population) | 100 | 100 | 104 | 104 | 106 | 106 | 125 | 119 | 146 | 130 | 165 | 138 | 180 | 144 | 193 | 149 |
| Orchard Heaters-(Agriculture) | 100 | 100 | 102 | 102 | 103 | 103 | 107 | 112 | 113 | 121 | 118 | 130 | 128 | 140 | 139 | 149 |
| WASTE BURNING | | | | | | | | | | | | | | | | |
| Agriculture Debris-(Agriculture) | 100 | 100 | 102 | 102 | 103 | 103 | 107 | 112 | 113 | 121 | 118 | 130 | 128 | 140 | 139 | 149 |
| Forest Management-(Forest & Fisheries) | 100 | 100 | 100 | 102 | 100 | 103 | 120 | 111 | 130 | 118 | 141 | 126 | 155 | 134 | 171 | 142 |
| Range Improvement-(Agriculture) | 100 | 100 | 102 | 102 | 103 | 103 | 107 | 112 | 113 | 121 | 118 | 130 | 128 | 140 | 139 | 149 |
| Dumps[3] | 100 | 100 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Conical Burners-(Manufacturing-lumber products & furniture) | 100 | 100 | 111 | 104 | 123 | 108 | 158 | 132 | 192 | 158 | 235 | 188 | 286 | 221 | 348 | 258 |
| Incinerators-(Population) | 100 | 100 | 104 | 104 | 106 | 106 | 125 | 119 | 146 | 130 | 165 | 138 | 180 | 144 | 193 | 149 |
| Other-(Population) | 100 | 100 | 104 | 104 | 106 | 106 | 125 | 119 | 146 | 130 | 165 | 138 | 180 | 144 | 193 | 149 |
| MISCELLANEOUS AREA SOURCES | | | | | | | | | | | | | | | | |
| Wild Fires-(Constant) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Structural Fires-(Population) | 100 | 100 | 104 | 104 | 106 | 106 | 125 | 119 | 146 | 130 | 165 | 138 | 180 | 144 | 193 | 149 |
| Farming Operations-(Agriculture) | 100 | 100 | 102 | 102 | 103 | 103 | 107 | 112 | 113 | 121 | 118 | 130 | 128 | 140 | 139 | 149 |
| Construction & Demolition-(Contract Construction) | 100 | 100 | 105 | 104 | 111 | 108 | 137 | 130 | 171 | 155 | 213 | 183 | 268 | 215 | 337 | 249 |
| Unpaved Roads-(Population) | 100 | 100 | 104 | 104 | 106 | 106 | 125 | 119 | 146 | 130 | 165 | 138 | 180 | 144 | 193 | 149 |
| Other-(Population) | 100 | 100 | 104 | 104 | 106 | 106 | 125 | 119 | 146 | 130 | 165 | 138 | 180 | 144 | 193 | 149 |

[1] From Table B.3.9

[2] Special Study - Please refer to section on Fossil Fuel Electric Generating Plants.

[3] Future emissions are assumed negligible.

SECTION 4. - AIR QUALITY MONITORING AND AIR QUALITY MODELING


## ACKNOWLEDGMENTS

The discussion of air quality models presented in this section utilizes significant portions of a report [28] prepared by Dr. Ronald Y. Wada. This report titled A Critical Assessment of the Role of Computer Models In Air Quality Planning and Decision-Making, discusses the technical approaches utilized in air quality modeling and the use of air quality models in planning and decision-making processes.

We wish to express our appreciation to Dr. Wada for allowing the use of his work.

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(continued)

# 4. AIR QUALITY MONITORING AND AIR QUALITY MODELING

## 4.1 AIR QUALITY MONITORING SYSTEMS AND DATA BASES

The air quality monitoring program operating in California provides data necessary to meet a number of objectives [1]:

- -- To assess air quality in each air basin.
- -- To determine compliance with air quality standards and with rules pertaining to significant deterioration of air quality.
- -- To determine the long-term trends of air pollutant concentrations and the effectiveness of State and local control programs.
- -- To establish control strategies, appropriate air pollution control rules and regulations, and land use plans.
- -- To determine the relationship between pollutant concentrations and their effects on man, animals, vegetation, property and visibility.
- -- To implement air pollution episode emergency action systems and agricultural burning decisions.

These objectives, together with practical considerations, are the basic determinants of the existing monitoring network in the State of California. The practical considerations include the selection of pollutants to be monitored, the determination of the number and location of sampling sites, the selection of appropriate instrumentation, analytical techniques, sampling frequencies, and the development of applicable data handling and analysis procedures [3]. Practical considerations should also include assuring traceable calibration between different instrumental methods and station locations. The amount of funding available is in most cases the major consideration in the design, operation and expansion of monitoring networks.

### 4.1.1 Existing Networks

The air pollutants measured and recorded at stations in the California network include photochemical oxidants, ozone, carbon monoxide, nitrogen dioxide, nitric oxide, total oxides of nitrogen, sulfur dioxide, total hydrocarbons, methane, lead and particulate matter [4]. The types of pollutants monitored and the sampling period and frequency for these pollutants are a function of the respective ambient air quality standard, instrumentation, and agency practices. Hourly concentrations are recorded for all pollutants except suspended particulate matter, and the highest hourly value each day is recorded as the maximum-hour (or max-hour) concentration. Hourly concentrations are averaged for those pollutants with standards requiring a longer averaging period, e.g., the 8-hour standard for carbon monoxide. For suspended particulate matter, a 24-hour sampling period is used to collect data. The frequency of particulate sampling is a function of the agency. The Air Resources Board recommends a sample every sixth day; the districts vary from every sixth day to every other day [4]. The highest 24-hour concentration measured during the year and the annual geometric mean of all samples are compared with the standards to determine compliance. Samples for particulate lead analyses are collected in the same manner as suspended particulate matter samples except different filter materials are used. The ARB recommends a 3-day sampling frequency. The analyses of the samples collected during a month's period are averaged to determine compliance with the 30-day average lead standard.

Ambient concentrations of one or more gaseous pollutants are measured continuously at 131 air monitoring stations in California. Oxidants are measured at 120 stations. Samples for suspended particulate matter are collected at 189 stations [2]. The Air Resources Board operates 20 of these air monitoring stations. These stations are capable of monitoring continuously six to eight pollutants and wind direction and speed. Additionally, 18 of these stations are operated by local air pollution control districts under contract to the Air Resources Board. The locations of the stations in the State-supported network are shown in Figure 4.1. The remainder of the stations are operated as part of the local air pollution districts' control programs.

Data from all State and air pollution control district air monitoring stations are received, processed and published by the Air Resources Board. The data are published on a regular basis in quarterly reports [5] and also in special publications [6,7]. These data are also forwarded to the Environmental Protection Agency for inclusion in the Storage and Retrieval of Aerometric Data (SAROAD) System. The SAROAD System is an ambient air quality data bank maintained by the Environmental Protection Agency. SAROAD also contains information on the scope of the monitoring activities throughout the nation. Summaries of monitoring and air quality data are published annually by EPA [8].

### 4.1.2 Mobile Monitoring Stations and Special Studies

The Air Resources Board, the California Department of Transportation and some local air pollution control districts have mobile monitoring vans and trailers. The majority of these stations have the capability of continuously monitoring all the gaseous pollutants monitored at fixed stations. The ARB mobile stations also measure wind speed and direction.

The use of these mobile stations is a function of the operating agency. The Bay Area Air Pollution Control District uses vans for calibration of $SO_2$ and $H_2S$ monitoring instruments operated by refinery companies, for surveillance of $SO_2$ and $H_2S$ in complaint areas, and for areawide air monitoring purposes. These activities are listed in decreasing priority [9].

# FIGURE 4.1

STATE OF CALIFORNIA
AIR RESOURCES BOARD

## AIR RESOURCES BOARD SUPPORTED AIR QUALITY MONITORING NETWORK

The Air Resources Board uses vans for special studies to [10]:

-- Fulfill obligations to monitor air quality in all air basins in the state.

-- Determine optimal location of fixed stations by identifying peak concentration points.

-- Complement existing fixed station monitoring systems (emergency episodes).

-- Crosscheck existing monitoring station data.

-- Audit local air pollution control district monitoring stations.

-- Participate in enforcement and complaint investigation activites.

The residence time of the Air Resources Board mobile stations at any site ranges from 2 to 6 weeks depending on the objectives of the study. The air quality data obtained from these special ARB studies are published in the quarterly air quality data reports of the Air Resources Board [11].

### 4.1.3 Criteria for the Number of Monitoring Stations

The U.S. Environmental Protection Agency has promulgated regulations concerning air monitoring in all Air Quality Control Regions (AQCRs). These regulations specify what pollutants are to be monitored and the minimum number of monitoring stations [12].

The minimum number of stations and the pollutants to be monitored for the AQCRs in California are given in Table 4.1. Table 4.1 also gives the number of monitoring sites in existence in 1973 and 1975. The number of monitors required depends on the Priority Classification, i.e.,

TABLE 4.1

SUMMARY TABLE OF AIR QUALITY MONITORING SYSTEMS BY AIR BASIN[(a)]

| Air Basin | Pollutant | Priority Classification Using 1974 Air Quality Data[(b)] | Monitors Required | Monitors in Use 1973 | Monitors in Use 1975 | Additional Monitors Required |
|---|---|---|---|---|---|---|
| North Coast | Particulate | I | 5 Hi-Vol<br>1 Tape sampler | 21 Hi-Vol<br>5 Tape | 14 Hi-Vol<br>2 Tape | --<br>-- |
| | $SO_2$ | III | 1 Bubbler | 0 | 1 Bubbler | -- |
| | CO | III | 0 | 0 | 1 | -- |
| | $NO_2$ | III | 0 | 1 | 0 | -- |
| | $O_x$ | III | 0 | 1 | 0 | -- |
| San Francisco Bay Area | Particulate | II | 3 Hi-Vol<br>1 Tape | 19 Hi-Vol<br>23 Tape | 21 Hi-Vol<br>23 Tape | --<br>-- |
| | $SO_2$ | III | 1 Bubbler | 11 Cont.<br>3 Bubbler | 11 Cont.<br>24 Bubbler | -- |
| | CO | I | 8 | 15 | 17 | -- |
| | $NO_2$ | III | 0 | 3 Bubbler<br>13 Cont. | 4 Bubbler<br>17 Cont. | --<br>-- |
| | $O_x$ | I | 8 | 22 | 27 | -- |
| North Central Coast | Particulate | I | 7 Hi-Vol<br>2 Tape | 9 Hi-Vol<br>7 Tape | 5 Hi-Vol<br>5 Tape | 2 Hi-Vol<br>-- |
| | $SO_2$ | III | 1 Bubbler | 0 | 1 Bubbler | -- |
| | CO | III | 0 | 4 | 3 | -- |
| | $NO_2$ | III | 0 | 5 | 4 | -- |
| | $O_x$ | I | 2 | 7 | 9 | -- |

TABLE 4.1 (continued)

| Air Basin | Pollutant | Priority Classification Using 1974 Air Quality Date(b) | Monitors Required | Monitors in Use 1973 | Monitors in Use 1975 | Additional Monitors Required |
|---|---|---|---|---|---|---|
| South Central Coast | Particulate | II | 3 Hi-Vol<br>1 Tape | 2 Hi-Vol<br>1 Tape | 3 Hi-Vol<br>2 Tape | --<br>-- |
| | $SO_2$ | III | 1 Bubbler | 0 | 0 | 1 Bubbler |
| | CO | III | 0 | 1 | 1 | -- |
| | $NO_2$ | III | 0 | 1 | 2 | -- |
| | $O_x$ | I | 1 | 2 | 2 | -- |
| South Coast | Particulate | I | 28 Hi-Vol<br>8 Tape | 38 Hi-Vol<br>11 Tape | 41 Hi-Vol<br>21 Tape | --<br>-- |
| | $SO_2$ | II | 1 Continuous<br>3 Bubbler | 20 Cont.<br>4 Bubbler | 24 Cont.<br>7 Bubbler | --<br>-- |
| | CO | I | 11 | 30 | 35 | -- |
| | $NO_2$ | I | 10 | 33 Cont.<br>4 Bubbler | 35 Cont.<br>7 Bubbler | -- |
| | $O_x$ | I | 11 | 31 | 48 | -- |
| San Diego | Particulate | I | 11 Hi-Vol<br>6 Tape | 3 Hi-Vol<br>3 Tape | 8 Hi-Vol<br>6 Tape | 3 Hi-Vol<br>-- |
| | $SO_2$ | III | 1 Bubbler | 3 Cont.<br>1 Bubbler | 5 Cont.<br>1 Bubbler | --<br>-- |
| | CO | I | 3 | 3 | 7 | -- |
| | $NO_2$ | III | 0 | 1 Bubbler<br>3 Cont. | 1 Bubbler<br>7 Cont. | --<br>-- |
| | $O_x$ | I | 3 | 6 | 8 | -- |

TABLE 4.1 (continued)

| Air Basin | Pollutant | Priority Classification Using 1974 Air Quality Data(b) | Monitors Required | Monitors in Use 1973 | Monitors in Use 1975 | Additional Monitors Required |
|---|---|---|---|---|---|---|
| Northeast Plateau | Particulate | I | 4 Hi-Vol<br>0 Tape | 5 Hi-Vol<br>1 Tape | 10 Hi-Vol<br>1 Tape | --<br>-- |
| | $SO_2$ | III | 1 Bubbler | 0 | 1 Bubbler | -- |
| | CO | III | 0 | 0 | 0 | -- |
| | $NO_2$ | III | 0 | 0 | 0 | -- |
| | $O_x$ | III | 0 | 0 | 0 | -- |
| Sacramento Valley | Particulate | II | 3 Hi-Vol<br>1 Tape | 16 Hi-Vol<br>6 Tape | 27 Hi-Vol<br>7 Tape | --<br>-- |
| | $SO_2$ | III | 1 Bubbler | 1 Bubbler | 2 Bubbler | -- |
| | CO | I | 3 | 4 | 4 | -- |
| | $NO_2$ | III | 0 | 4 Cont.<br>1 Bubbler | 5 Cont.<br>1 Bubbler | --<br>-- |
| | $O_x$ | I | 3 | 5 | 7 | --<br>-- |
| San Joaquin Valley | Particulate | I | 12 Hi-Vol<br>7 Tape | 18 Hi-Vol<br>11 Tape | 29 Hi-Vol<br>12 Tape | --<br>-- |
| | $SO_2$ | III | 1 Bubbler | 0 Cont.<br>1 Bubbler | 2 Cont.<br>1 Bubbler | --<br>-- |
| | CO | I | 4 | 7 | 9 | -- |
| | $NO_2$ | III | 0 | 5<br>1 Bubbler | 7 Cont<br>1 Bubbler | --<br>-- |
| | $O_x$ | I | 4 | 9 | 12 | -- |
| Great Basin Valleys | Particulate | I | 4 Hi-Vol<br>0 Tape | 3 Hi-Vol<br>0 Tape | 1 Hi-Vol<br>0 Tape | 3 Hi-Vol<br>-- |
| | $SO_2$ | III | 1 Bubbler | 0 | 1 Bubbler | -- |
| | CO | III | 0 | 0 | 0 | -- |
| | $NO_2$ | III | 0 | 0 | 0 | -- |
| | $O_x$ | III | 0 | 0 | 0 | -- |

TABLE 4.1 (continued)

| Air Basin | Pollutant | Priority Classification Using 1974 Air Quality Data(b) | Monitors Required | Monitors in Use 1973 | Monitors in Use 1975 | Additional Monitors Required |
|---|---|---|---|---|---|---|
| Southeast Desert | Particulate | I | 7 Hi-Vol<br>2 Tape | 8 Hi-Vol<br>3 Tape | 14 Hi-Vol<br>8 Tape | --<br>-- |
| | $SO_2$ | III | 1 Bubbler | 2 Cont. | 2 Cont. | -- |
| | CO | III | 0 | 6 | 6 | -- |
| | $NO_2$ | III | 0 | 4 Cont. | 4 Cont. | -- |
| | $O_x$ | I | 2 | 4 | 9 | -- |
| Mountain Counties | Particulate | III | 1 Hi-Vol<br>0 Tape | 8 Hi-Vol<br>0 Tape | 15 Hi-Vol<br>1 Tape | --<br>-- |
| | $SO_2$ | III | 1 Bubbler | 0 | 0 | 1 Bubbler |
| | CO | III | 0 | 0 | 1 | -- |
| | $NO_2$ | III | 0 | 0 | 0 | -- |
| | $O_x$ | III | 0 | 0 | 1 | -- |
| Lake County | Particulate | III | 1 Hi-Vol<br>0 Tape | 1 Hi-Vol<br>0 Tape | 2 Hi-Vol<br>0 Tape | |
| | $SO_2$ | III | 1 Bubbler | 0 | 1 Cont. | -- |
| | CO | III | 0 | 0 | 0 | -- |
| | $NO_2$ | III | 0 | 0 | 0 | -- |
| | $O_x$ | III | 0 | 0 | 0 | -- |

(a) From Air Quality Engineering Unit, Division of Technical Services, Air Resources Board. July 9, 1975, November 3, 1975.

(b) Reference: Federal Register, Vol. 36, No. 158 - Saturday, August 14, 1971.

I, II, or III. These classification criteria consider the maximum pollutant concentrations recorded in the AQCR with a classification of Priority I indicating higher levels of pollution.

It should be noted that the existing monitoring system in most areas of California greatly exceeds the minimum requirements of the Environmental Protection Agency [13].

### 4.1.4 Criteria for Locating Monitoring Stations

The placement or location of sampling stations in a network must be such that the data obtained by the stations will be of value in meeting the stated objectives of the monitoring program. With this in mind, the following criteria have been identified [3]. The different criteria reflect the different objectives of monitoring activities and a proposed monitoring site will not meet all criteria.

Criteria 1. Monitoring stations must be pollution oriented

> It is most important that areas most heavily polluted be identified and monitored. It is in these areas that progress toward meeting ambient air quality standards is most critical.

Criteria 2. Monitoring stations must be population oriented

> A portion of the network must be located according to the population distribution. This is particularly important during times of air pollution alerts and episodes.

Criteria 3. Sampling stations must be located to provide areawide representation of ambient air quality

> Data must be representative of the entire Air Quality Control Region. Areawide data is needed to show conformity to the ambient air quality standards. This includes both developed and undeveloped areas within the region. In the nonurban areas, increased consideration should be given to those areas where future land development is anticipated.

Criteria 4. Ambient monitoring stations must not be source or source category oriented

> In ambient monitoring, every effort is made to avoid a source oriented exposure unless the source influences a significant section of the public. However, a control regulation limiting the emissions from certain industrial activities would require that stations be located where compliance with the regulation can best be evaluated. This type of monitoring is set up at stack level or ground level as required under the applicable rules and regulations. Data collected from source testing by the Air Resources Board is not regularly published.

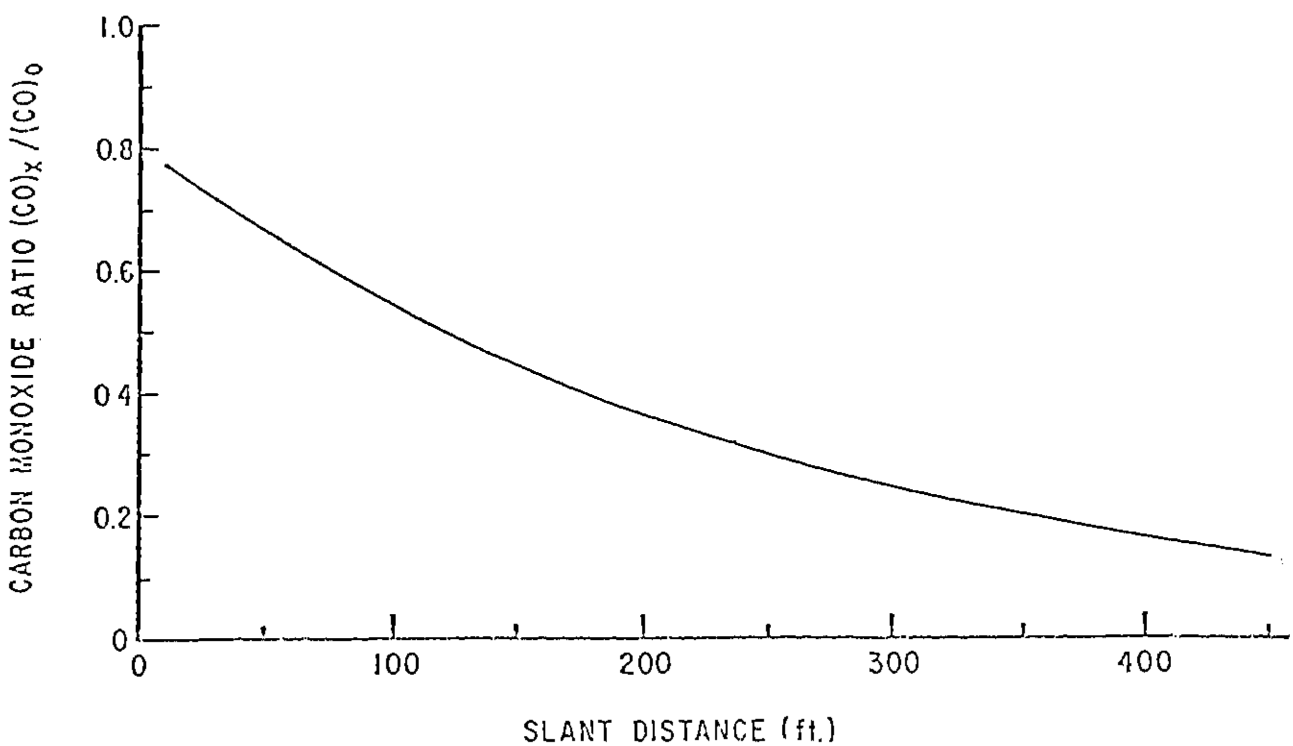
The air quality monitoring network should then comprise stations reflecting one or more of the above criteria. It should contain stations that are situated primarily to monitor the highest levels in the region, to measure population exposure, to measure pollution generated by specific classes of sources and to record the nonurban levels of pollution. In many cases a given station location will be capable of meeting more than one of the listed criteria, i.e., a station located in a densely populated area, besides measuring population exposure, will also monitor the effectiveness of controls on emissions from certain industrial activities if such emissions controls are part of the overall control strategy.

The preceding discussion would imply that monitoring systems are designed and established after a comprehensive, regionwide analysis of needs, objectives, and resources. This is not the case. The existing air quality monitoring network in the state has been developed in an incremental fashion. Different agencies throughout the state establish stations based on different site selection and monitoring criteria. The main reasons that have governed the location of a station were convenience and availability of a site rather than the selection of a location which had a definite purpose of determining the air quality of a particular area or layer of the atmosphere. The height above ground level of a station seemed to be unimportant. Many agencies still report air monitoring data as if all of the stations have the same physical characteristics with respect to height, area, sample collection methods, and calibration procedures [14].

### 4.1.5 Influence of Monitoring Site Location

The impact that site location can have on air quality data is shown by the plot of carbon monoxide concentration vs. slant height in Figure 4.2 [15]. (Slant height is the "line of sight" distance from the sampling probe inlet to the nearest motor vehicle traffic.)

FIGURE 4.2




RATIO OF CO CONCENTRATIONS VS DISTANCE FROM FREEWAY

" DEPRESSED SECTION " ALL STABILITY CLASSES

SOURCE: (15)

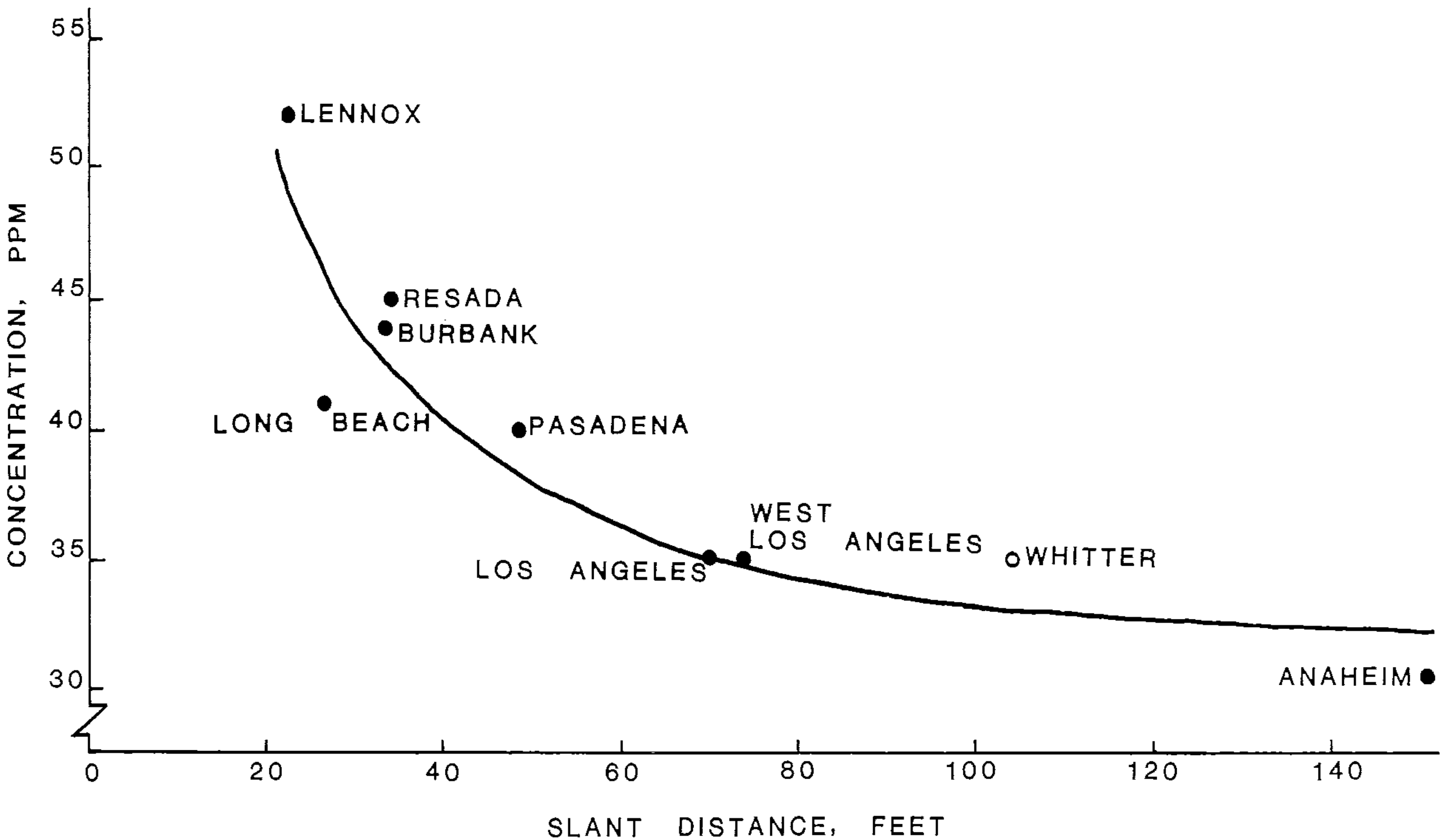
In Figure 4.2, $(CO)_o$ represents concentrations of carbon monoxide measured four feet above the highway median. $(CO)_x$ represents carbon monoxide concentrations measured at select distances from the median. The ratios $(CO)_x/(CO)_o$ are plotted to indicate the dependence of carbon monoxide concentrations on slant height. Figure 4.2 indicates a decreasing carbon monoxide concentration with increasing distance from the roadway.

This is an intuitively obvious relationship known for many years that has not been considered in reporting carbon monoxide data. This relationship between CO concentration and slant height is normally considered when establishing a monitoring site. The sampling probe must be set back a minimum distance from vehicular activity to avoid undue influence. However, the degree to which the slant height factor has been considered in the location of existing stations is uncertain. Also, the influence that slant height has on air quality data presently being recorded at these existing stations is also uncertain.

Figure 4.3, which presents a plot of 3-year maximum hourly averages of CO concentrations versus slant height [16], indicates an inverse relationship between average CO concentrations and slant height, i.e., increasing slant heights resulting in decreasing average concentrations. There are other factors that are unique to each monitoring site and that influence the CO concentrations recorded, e.g., motor vehicle activity and meteorological processes. However, the influence of slant height on existing air quality CO data is clearly demonstrated in Figures 4.2 and 4.3.

Research studies have been completed identifying a technique for quantifying the influence of slant height on CO concentrations and for adjusting CO air quality data to reflect this influence [15]. However, it is unlikely that an adjustment factor for CO data will be incorporated into air quality data banks. Since the needs of various users differ,

FIGURE 4.3




AVERAGES OF THE 1969-1970 ANNUAL MAXIMUM HOURLY CO CONCENTRATIONS AND SLANT DISTANCES AT AIR MONITORING STATIONS

SOURCE: (16)

it is considered more valuable to report unadjusted data and allow the individual users to make the adjustments for their particular needs [4]. Unfortunately, this approach requires a degree of expertise and familiarity with air monitoring practices and data that is seldom found in planning agencies.

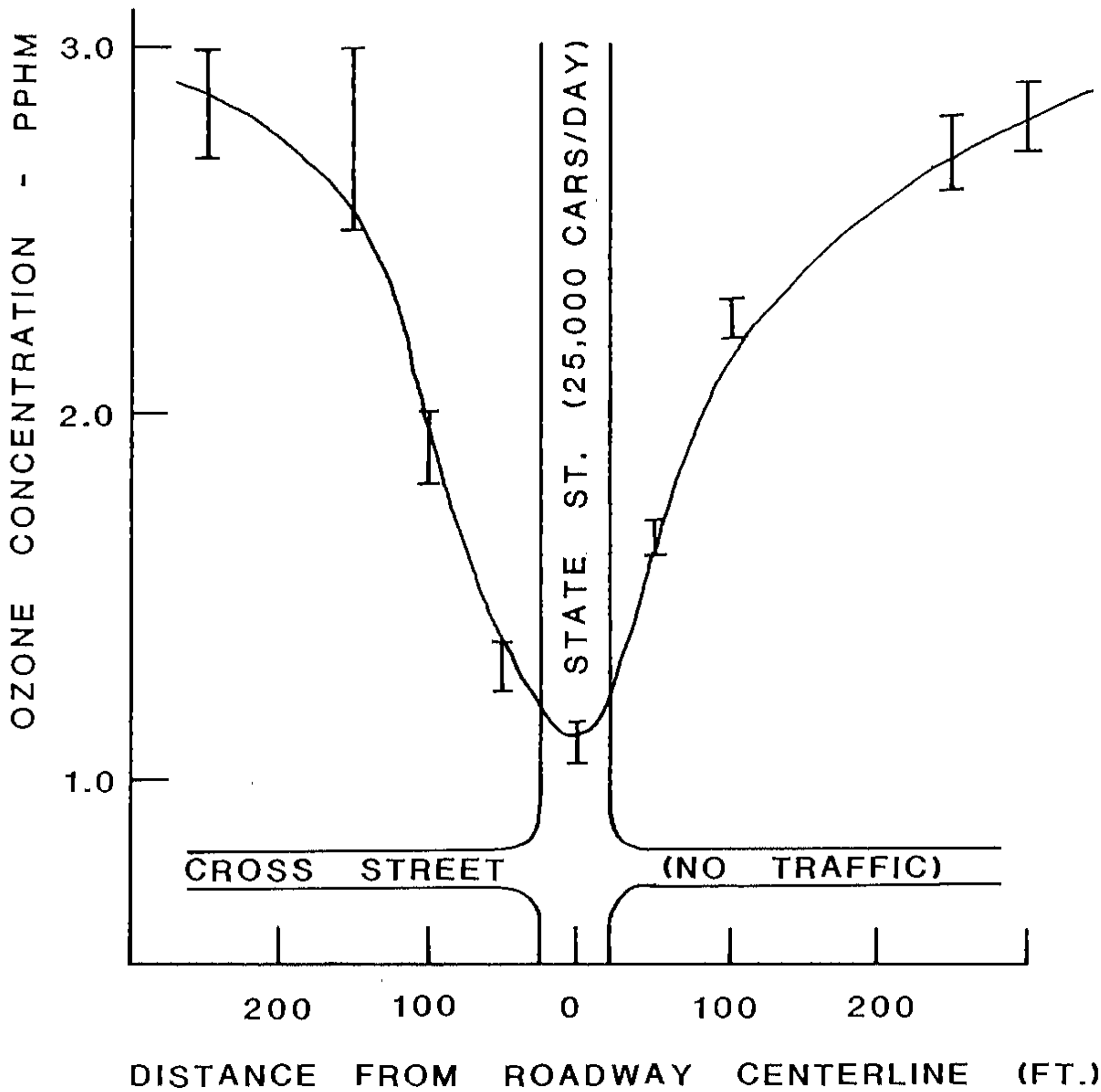
Another phenomenon which demonstrates the influence of monitoring site location on air quality data is the ozone depression experienced near heavily traveled roadways [17].

Unburned organic gases and nitrogen oxides combine under the action of sunlight to produce ozone in smog. The production of ozone by the photochemical reactions is a relatively slow process. Studies in smog chambers have shown that the ozone level does not rise until most of the available nitric oxide has disappeared by reaction. The reaction $NO + O_3 = NO_2 + O_2$ is responsible for this behavior. That reaction is so fast that ozone and nitric oxide cannot co-exist in any appreciable concentrations. This process is known as scavenging of ozone ($O_3$) by nitric oxide (NO).

Fresh vehicle exhaust, which contains high concentrations of nitric oxide, reduces ozone concentrations. Near roads, in areas of high traffic density or where exhaust fumes are trapped, the ozone level drops to very low values. This effect is demonstrated in Figure 4.4 which shows ozone concentrations as a function of perpendicular distance from a roadway [17]. The results shown in Figure 4.4 should be considered qualitative since the concentrations shown approach the level of sensitivity of the instrument used to measure oxidant [18].

This scavenging effect must be considered in locating fixed air monitoring stations. To obtain valid measurements of ozone (or oxidants since ozone is the principal constituent of oxidants), monitoring sites should be located well away from sources of nitric oxide such as power plants and heavily traveled roadways.

FIGURE 4.4




MEASURED OZONE CONCENTRATIONS AS A FUNCTION OF PERPENDICULAR DISTANCE FROM A BUSY STREET. DATA FROM STATE STREET AND CALLE LAURELES, SANTA BARBARA, CALIFORNIA. SOURCE: (17)

In summary, air quality monitoring stations are pollutant oriented resulting in a bias in the concentrations measured [11]. Monitoring stations are characterized as being oriented for primary pollutants or oriented for secondary pollutants. Since air quality data from different stations are influenced by a combination of variables unique to each station, care should be exercised when making comparisons of air quality data from different monitoring stations.

# 4. AIR QUALITY MONITORING AND AIR QUALITY MODELING

## 4.2 AIR QUALITY MODELING

### 4.2.1 Introduction

Air quality modeling is a systematic method for quantitatively relating pollutant emissions from sources to pollutant concentrations at receptors. This involves either analytical approaches based on the theoretical treatment of atmospheric dispersion and transport or empirical approaches based on relationships deduced from observed emissions and air quality data. The analytical models are commonly termed dispersion models and the empirical models are called statistical models.

In its simplest form, a model relates ambient pollutant concentrations (x) to pollutant source emission rates (Q) and a background concentration (b),

$$x = KQ + b$$

The variable K is a function of atmospheric conditions and the spatial relationships between a source and a receptor. Depending on the sophistication of the model, K can be highly complex or very simple.

The development and application of air quality models requires careful evaluation of the situation and the models available to insure selection of the best approach. Air quality models are at a stage of development such that no model is capable of completely simulating the many possible interactions of pollutant emissions and meteorological processes. Many models are well suited for particular applications and a variety of techniques can be used to satisfy a particular application.

It is unlikely that any one model will be acceptable or appropriate for all applications in a given region. Optimally, a variety of techniques should be available. The choice of any one of the alternatives depends primarily on the quality of the input data, the budgetary resources of the user, and the nature of the problem to be investigated. The components of an air quality model are shown in Figure 4.5. As illustrated, a model comprises four major inputs that include the following areas:

1. Emissions assessment;
2. meteorological processes;
3. topography; and
4. applicable chemical reactions.

A geocoded emissions inventory provides the pollutant data base for an air quality model. These data must identify emission quantities along with spatial and temporal distributions. Meteorological processes constitute the basic dynamic framework for predicting pollutant concentrations in the atmosphere. In general, climatic summaries provide a data base for operating the model and specifying expected conditions for a certain time or place. Specific meteorological data are used to simulate particular situations such as pollutant episodes. The fluid flow of atmospheric processes is sensitive to topographic features. Hills obstruct the flow, while valleys channel wind movement. Buildings and similar structures obstruct winds and complicate the prediction of pollutant movement. Many of the chemical reactions between pollutants and atmospheric constituents are a complex function of particular pollutants and meteorological processes.

The current field of air quality models covers a wide spectrum from the very simple proportional model to very complex and costly regional photochemical air quality models. The following sections cover the basic theory and approaches of air quality modeling, specific modeling techniques, and examples of the very simple proportional model. The following discussions are at times very technical. If interest is waning, go to Section 4.2.6 on Statistical Models. This is the suggested minimum reading on air quality modeling. It should be pointed out that the proportional model, the simplest of all models, has been the technique for almost all air quality control strategy evaluation completed to date. Consequently, familiarity with this model is essential.

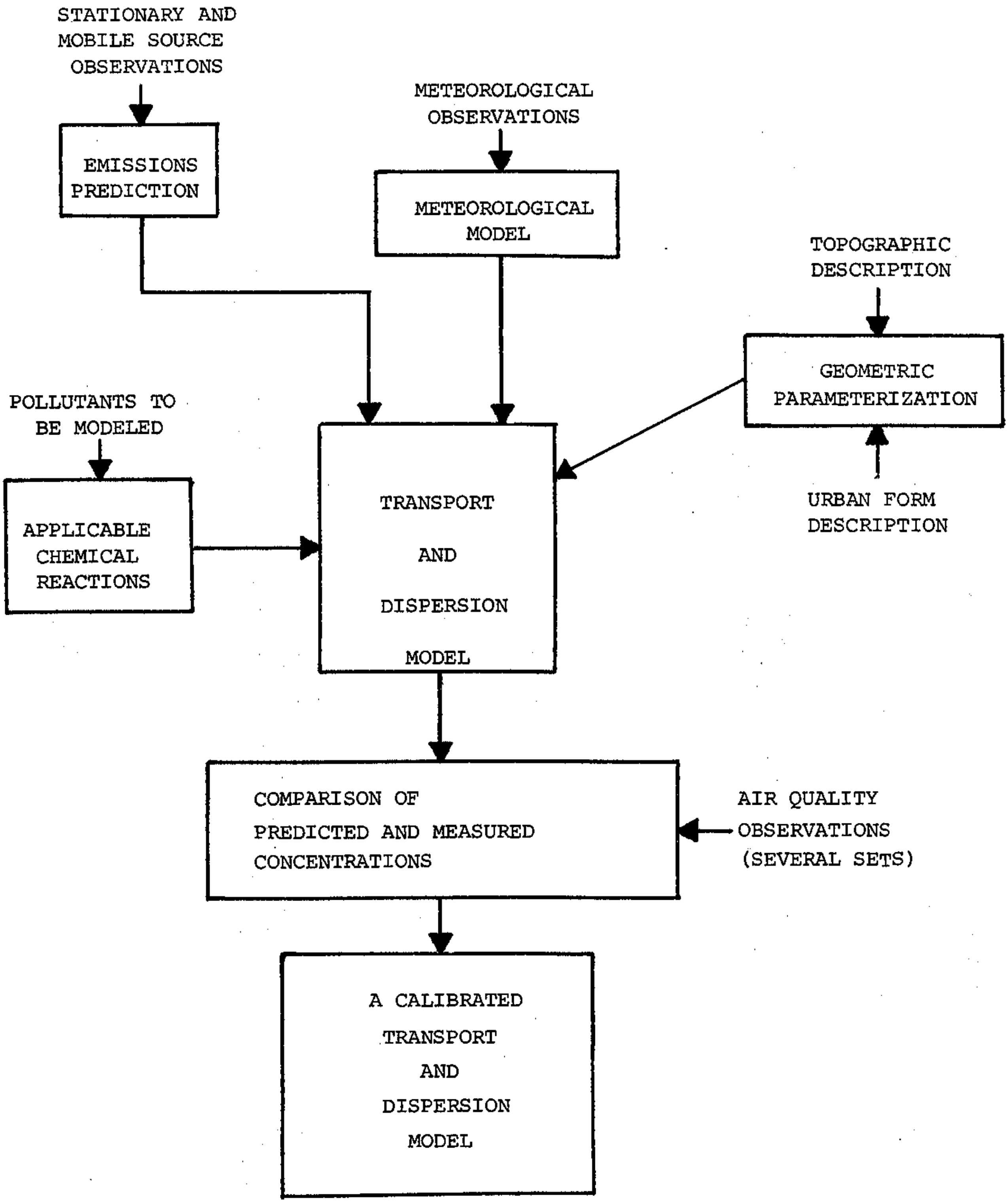



FIGURE 4.5
Components of an Air Quality Model

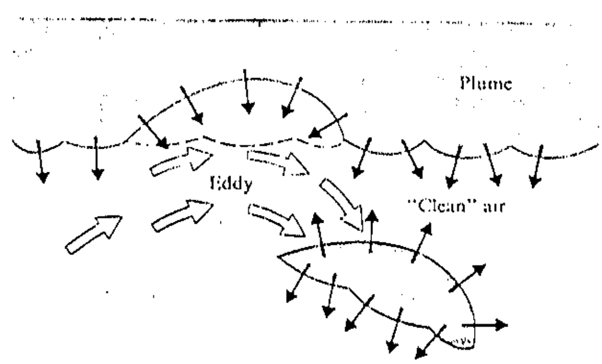
4.4.2 General Theory

Air quality models are designed to simulate the action of the atmosphere in mixing, modifying, and transporting pollutants. Pollutants are mixed by the physical process of turbulent dispersion.

When a stream of exhaust gases (a plume) is released into the atmosphere, small eddies of air act on the edge of the plume to mix the pollutants with the surrounding air (Figure 4.6). The edge of a plume has a large gradient (difference) in concentration between it and the ambient air.

**FIGURE 4.6**

**TURBULENT DISPERSION**




Grossly simplified view of how a turbulent eddy breaks up a plume and causes rapid mixing of pollutants with ambient "clean" air.

SOURCE: (20)

Pollutants will mix with the ambient air across this gradient by two processes. Mixing by molecular diffusion occurs by the interaction of pollutant molecules with air molecules. This is indicated by the thin arrows in Figure 4.6. Another more important mechanism for mixing and transporting pollutants is turbulent motion. The eddies associated with this turbulent motion affect sizeable volumes of the plume. A parcel of the plume moved by a turbulent eddy is shown in Figure 4.6. Turbulent eddies will produce a much more rapid mixing of the plume than molecular diffusion. For this reason, molecular diffusion is usually ignored in any analysis of pollutant dispersion.

In the process of turbulent motion, pollutants are modified by chemical as well as physical processes. These can be simulated by kinetic mechanisms comprising sets of chemical equations. The transport of pollutants is a function of regional winds, temperature inversions, and topographic features. Transport phenomena are usually accounted for in models by the specification of regional wind patterns based on wind observation data.

The set of equations governing the behavior of a fluid system such as the atmosphere consists of the conservation equations for mass, momentum (Navier-Stokes equations), and energy. In the most general case these equations are coupled as well as nonlinear, thus posing a formidable computational problem. In the case of air pollution, if it is assumed that the presence of the pollutants does not alter the behavior of the atmosphere on the scales of interest, then the conservation of mass equation becomes decoupled from the others. This assumption is quite valid in most cases. Only very high concentrations of $NO_2$ or particulate matter (~several ppm for $NO_2$, ~several hundred $\mu g/m^3$ for particulates) result in a significant perturbation of the flow field due to their influence on the radiative exchange processes of the ambient atmosphere. Further, if the atmospheric flow field is described by a combination of empirical observations such as wind and stability data, and reasonable assumptions are made to fill data gaps, the momentum and energy equations may be eliminated from consideration.

After appropriate assumptions and manipulations, the conservation of mass equation may be written to represent the basic transport-dispersion processes of the atmosphere as follows:

$$\frac{\partial C_i}{\partial t} + u\frac{\partial C_i}{\partial x} + v\frac{\partial C_i}{\partial y} + w\frac{\partial C_i}{\partial z} = \frac{\partial}{\partial x}\left(Kx\frac{\partial C_i}{\partial x}\right) + \frac{\partial}{\partial y}\left(Ky\frac{\partial C_i}{\partial y}\right) \qquad (1)$$

$$+ \frac{\partial}{\partial z}\left(Kz\frac{\partial C_i}{\partial z}\right) + [\pm R_i\,(C_i, \ldots, Cn)] + (\pm S_i)$$

Where,

$t$ = time

$x,y,z$ = Cartesian coordinates

$u,v,w$ = components of the mean wind velocity in each of the coordinate directions respectively

$K_x,K_y,K_z$ = eddy diffusivity coefficients in each direction that are related to temperature stability, wind shear, surface roughness and convective heat flux

$R_i$ = rate of generation of the i-th pollutant by chemical reactions and may be a function of the concentrations of other pollutants

$S_i$ = net source term which considers both emissions and losses by deposition

$\frac{\partial C_i}{\partial t}$ = change in concentration of pollutant C with respect to time

$\frac{\partial C_i}{\partial x}$ = change in concentration of pollutant $C_i$ with respect to distance in the x direction. The other partial derivatives ($\partial C_i/\partial y$ and $\partial C_i/\partial z$) indicate similar relationships

The concentration $C_i$ of each of the $i = 1, \ldots, n$ pollutants considered may be written as an equation of this form.

The change of concentration with time is expressed in the first term of the dispersion equation. Steady-state solutions are obtained by models which assume this term ($\partial C_i/\partial t$) to be zero, i.e., no change in concentration with time. The next three terms represent the advection or transport of pollutants by the mean winds. The first three terms on the right hand side of the equation allow for pollutant dispersion by turbulence. The last two terms account for the generation of the pollutant, the emission into the atmosphere and the losses by chemical reaction, deposition, etc. This equation and its associated boundary conditions form the basis for all the dispersion models discussed in this report. Figure 4.7 presents a schematic representation of this basic equation.

In the case of air pollution, since it is assumed that the presence of the pollutants does not alter the behavior of the atmosphere, the dispersion equation is decoupled from the equations governing atmospheric motions. Once u, v, w, $K_x$, $K_y$, and $K_z$ are specified, the dispersion relation may be solved.

The derivation of the parameters mentioned above and effects of the atmosphere on other aspects of pollutant dispersal are discussed in the section on meteorology submodels. The following sections discuss the solution techniques utilized to solve the dispersion and transport relationships once the atmospheric parameters are specified.

### 4.2.3 Dispersion Models

Dispersion models are generally differentiated by the approach utilized for solution of the dispersion and transport relationships shown in Equation 1. Assumptions inherent in deriving the solutions limit the range of cases that can be handled. Before any individual model is used, the assumptions involved in the derivations and the limitations of each model type must be understood. The basic types of dispersion models and their assumptions, formulations, and input requirements are presented after a brief discussion of sources, scales of analysis, and coordinate systems.

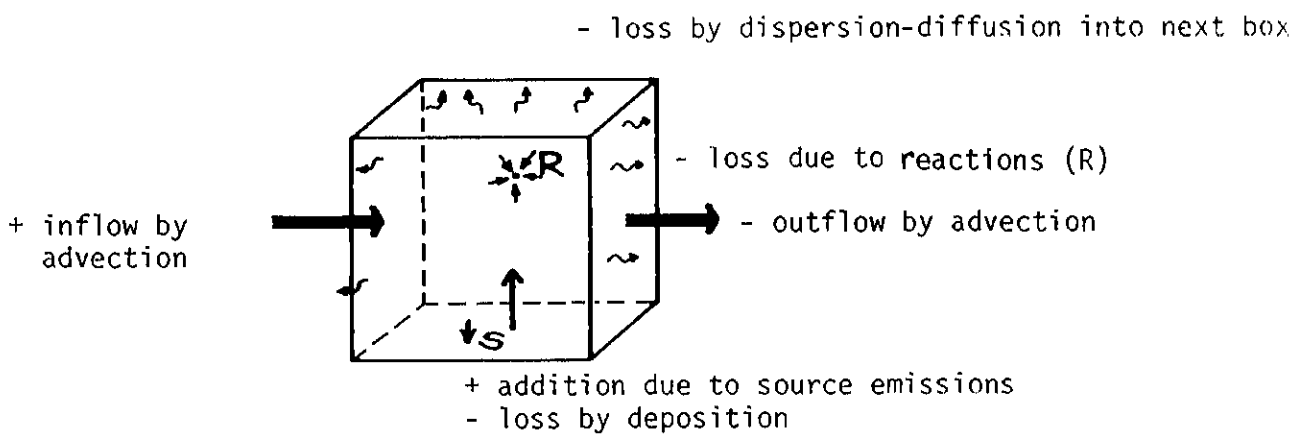
There are three general configurations of emission sources: point sources, line sources, and area sources. Point sources, as the name implies, emit pollutants from one specific point in space. Power plants, sulfuric acid plants, and incinerators are examples of point sources. Line sources are an idealized situation in which pollutants are emitted

FIGURE 4.7

REPRESENTATION OF THE BASIC

TRANSPORT - DISPERSION EQUATION

The change in concentration in a given time equals the sum of·



at a constant and uniform rate along a line. Freeways and heavily-traveled streets are treated as line sources for dispersion modeling. The area source approximation is used when numerous small point and line sources result in uniform emissions from an area. Urban areas and large parking lots have been idealized as area sources for dispersion modeling. Typical units for the emission rates from these source configurations are given below:

| | |
|---|---|
| Point sources | grams/second |
| Line sources | grams/meter-second |
| Area sources | grams/meter$^2$-second |

The scales of analysis for air quality modeling of interest in land use planning are the microscale and the mesoscale. Microscale analysis deals with the localized impact of a single source or a group of sources. The methodology for microscale air quality estimates is based on the Gaussian dispersion model and is usually applied only to point and line sources. The study area for a microscale analysis ranges from 1 to 10 kilometers across in the direction of the average wind. A mesoscale or airshed analysis is regional in scope and is normally used when the area source approximation is being made. A coordinate system is used to delineate grid squares for a study area (e.g., a checker board pattern) and area source emission rates for each grid square are identified. This allows the use of a simple model for estimating the dispersion of pollutants. When emissions are not assigned to grids, they are assumed to be uniformly distributed throughout the study area.

One of the basic differences between individual mesoscale models is the choice of the coordinate system to be employed. Airshed models may be classified according to the type of coordinate system used. The first type of model employs a coordinate system which is fixed with respect to the ground. It is known as an Eulerian coordinate system. The second type attaches its coordinate system to a fictitious vertical air column which moves horizontally in the direction of the large scale winds. This form is often called the Lagrangian Model.

The more common coordinate system is the Eulerian frame in which sources are located, winds are described, and concentrations are computed or measured at specific points in a fixed grid. However, the dispersion part of the pollution problem is more naturally formulated in terms of a moving air parcel or Lagrangian reference frame. Some models attempt to use this method. Since sources are more easily described in a fixed frame, and conservation of mass is more difficult to express in Lagrangian coordinates, moving cell models incorporate a quasi-Lagrangian coordinate set.

The meteorological factors in many situations are the most important variables in air quality estimates. Consider the fact that for a given year, the total daily emissions into the atmosphere from a region are essentially the same and that the day to day differences in air quality for that region depend entirely on the differences in meteorology. Wind behavior is almost invariably separated into two parts for modeling. Relatively large scale motions are described as transporting the pollution from sources to receptor. Relatively small scale motions are described as dispersing and mixing the pollutant as it is transported. Additional meteorological considerations include mixing layer, atmospheric stability, and solar radiation.

To be meaningful, estimates of air quality must be given in terms of pollutant concentration and averaging time. When estimates are given with averaging times identical to those of the ambient air quality standards, direct comparisons with the standards are possible. However, several methodologies for estimating air quality result in estimates with averaging times different than the standards. To compare these estimates with the standards, they must be converted to the same averaging time. The mathematical technique for this conversion, known as Larsen's model, is discussed later in this section.

4.2.3-1 The Gaussian Formulation

Historically, efforts to further simplify the basic dispersion equation (Equation 1) so that it could be solved analytically have resulted in the familiar Guassian plume formulation. The assumptions utilized by Turner [19] in the development of solutions for the Guassian dispersion model for point, line, and area sources are given below:

1) The average wind direction determines the x-axis and the average wind speed used is representative of the mixing layer.

2) There is continuous and constant emission from the source, or the period of emission is equal to or greater than the travel time to the downwind position of interest, so that dispersion in the direction of transport may be neglected, i.e.,

$$\frac{\partial C_i}{\partial x} > K_x \frac{\partial^2 C_i}{\partial x^2} \qquad \text{and } S_i \text{ is constant.}$$

3) The pollutant being diffused is a stable gas or particulate matter less than 20 microns diameter which remains suspended in the air over long periods of time, i.e., $R_i = 0$.

4) Except where specifically mentioned, the plume constituents are normally distributed in both the cross wind and vertical directions.

5) The equation of continuity is fulfilled, i.e., none of the pollutant emitted is removed from the plume as it moves downwind and there is complete reflection at the ground.

6) The standard deviations ($\sigma$'s) used by Turner represent time periods of about 10 minutes and are empirically derived parameters of the atmosphere's ability to disperse the plume constituents.

Based on the above assumptions, Equation 1 is simplified to the following form:

$$u \frac{\partial C_i}{\partial x} = K_y \frac{\partial^2 C_i}{\partial y^2} + K_z \frac{\partial^2 C_i}{\partial z^2} + S_i \qquad (2)$$

The substitution of $\sigma_y(x)^2 = 2K_y\frac{x}{\bar{u}}$ and $\sigma_z(x)^2 = 2K_z\frac{x}{\bar{u}}$ yields a solution for a point source at ground level with the following form:

$$C_i = \frac{S_i}{\pi\bar{u}\sigma_y\sigma_z} \exp - 1/2 \left[\frac{Y^2}{\sigma_y^2} + \frac{Z^2}{\sigma_z^2}\right] \qquad (3)$$

Where,

$C_i$ = concentration of pollutant at receptor

$S_i$ = emission rate of pollutant $i$

X,Y,Z = coordinate values for receptor (Figure 4.8 )

$\bar{u}$ = mean wind speed

$\sigma_y,\sigma_z$ = empirically derived measures of the eddy diffusivity ($K_y,K_z$) of the atmosphere, i.e., how well the atmosphere can disperse the pollutants.

The important features [19] of Equation 3 which apply to a point source at ground level, are:

1. The downwind concentration at any location is directly proportional to the emission rate of the sources.

2. The more turbulent the atmosphere, the more rapid the spread of the plume in the transverse direction. Turbulence increases the eddy diffusivities $K_y$ and $K_z$.

3. The maximum concentration at ground level is found directly downwind, on the plume line, and is inversely proportional to the downwind distance from the source.

4. The maximum concentration decreases with higher wind speeds, $\overline{u}$. Even on the plume line, where at ground level there is no explicit dependence on $\overline{u}$ (because $\sigma_y$ and $\sigma_z$ are inversely proportional to $\overline{u}$), concentrations will actually decrease with increasing wind. This is because the eddy diffusivity K in the equation above increases with wind speed due to increased mechanical turbulence.

These are the four key features of most Guassian models used to describe the dispersion of emissions from a point source.

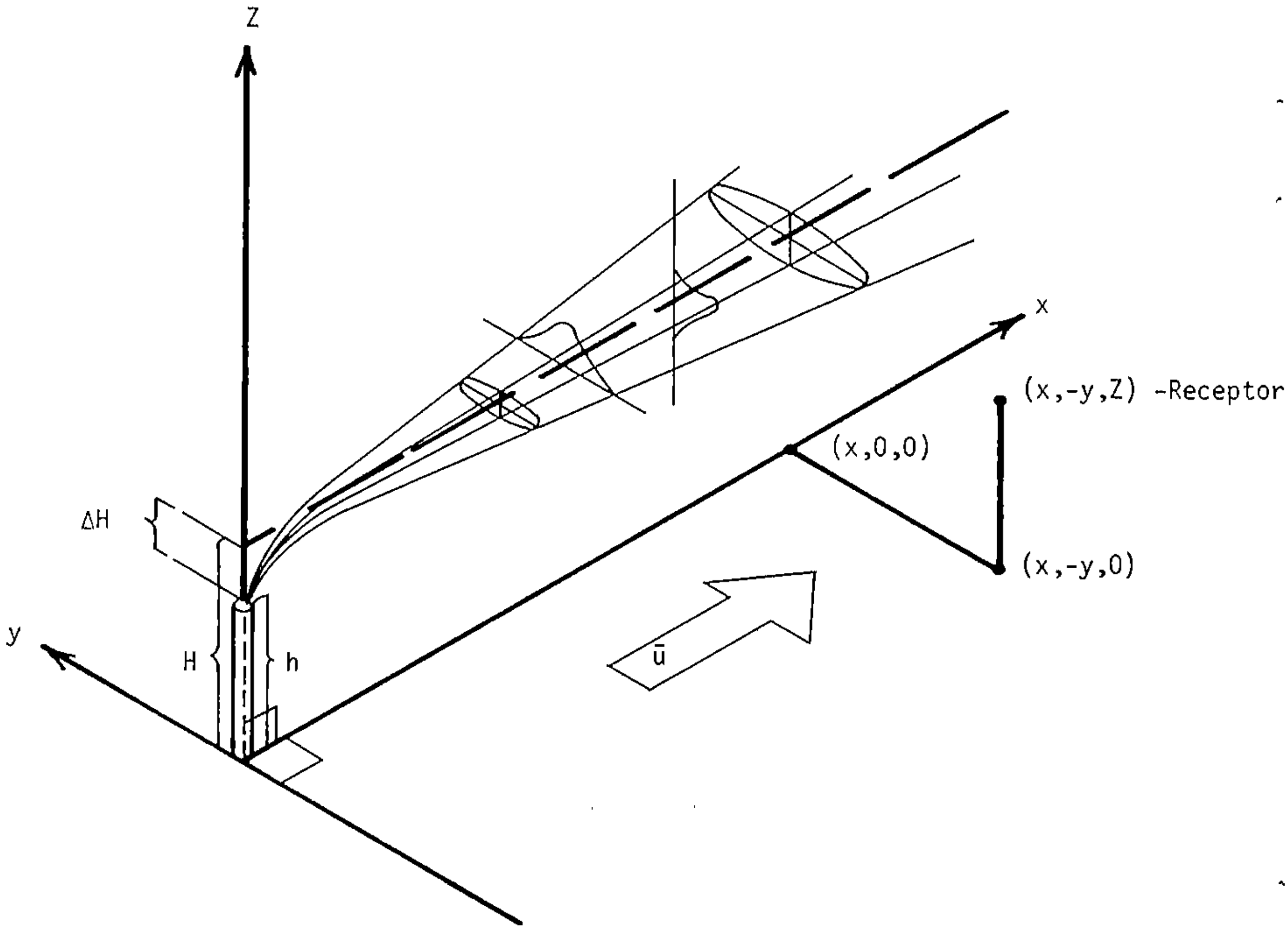
The spatial relationship between the emissions source and receptor must be established through a coordinate system. A commonly accepted coordinate system used by Turner [19] for point sources is shown in Figure 4.8. In the system considered here, the origin is at ground level at or beneath the point of emission, with the x-axis extending horizontally in the direction of the mean wind. The y-axis is in the horizontal plane and perpendicular to the x-axis, and the z-axis extends vertically. The plume travels along or parallel to the x-axis.

For line and area sources, the pollutant concentration along the y-axis (a horizontal line perpendicular to the wind direction) is assumed uniform. Therefore, the y coordinate is not used in estimating pollutant concentrations for these sources.

The plume formulas have been used extensively in the past and have formed the basis of many of the air quality models currently available. However, the simplicity of the classical Gaussian models has been achieved through assumptions which restrict their application. The requirement for a uniform and constant wind over the entire three-dimensional area of concern is contrary to the known behavior of winds. Wind speed generally increases with height in the lower several hundred

FIGURE 4.8

COORDINATE SYSTEM SHOWING GAUSSIAN DISTRIBUTIONS IN THE HORIZONTAL AND VERTICAL




h = Actual Stack Height
H = Effective Stack Height
ΔH = Initial Plume Rise Due to the Buoyancy and momentum of Stack Gases
ū = Mean Wind Velocity and Direction

SOURCE: (19)

meters of the atmosphere. Consequently, the assumption of a single wind speed will tend to underestimate concentrations at lower heights and overestimate at higher heights. Also, these equations breakdown in the case of very light or calm winds since the wind speed is in the denominator, i.e., division by zero. The existence of a temperature inversion or stable layer prevents the upward spread of pollutants. The region below such an inversion is called the mixing layer and the thickness of this layer is called the mixing depth. When certain meteorological conditions exist, the equations are modified so that the vertical plume material distribution becomes uniform at a certain downwind distance from the point where the plume encounters the mixing level. The distribution in the horizontal remains Gaussian.

Since meteorological variables in the model are assumed to be uniform in time and space, the use of the model is restricted to regions of relative flat terrain without bodies of water or tall buildings in the immediate vicinity. Coastal regions with land/sea breeze circulation patterns and generally hilly or mountainous surrounding terrain are poor locations for application of this model. Second, the plume formulation cannot account for chemical reactions that are more complex than a simple decay mechanism due to the steady-state assumption. Plume model applications are then restricted to primary pollutants such as sulfur dioxide, particulates, and carbon monoxide.

The plume formulation is the only technique developed so far to describe individual point and line source emissions, such as from power plant stacks and highway segments. In situations where sources are isolated and analyzed individually, the Gaussian plume model may be "fine-tuned" to yield results which are much improved over a multiple source analysis.

### Gaussian Puff Formulation

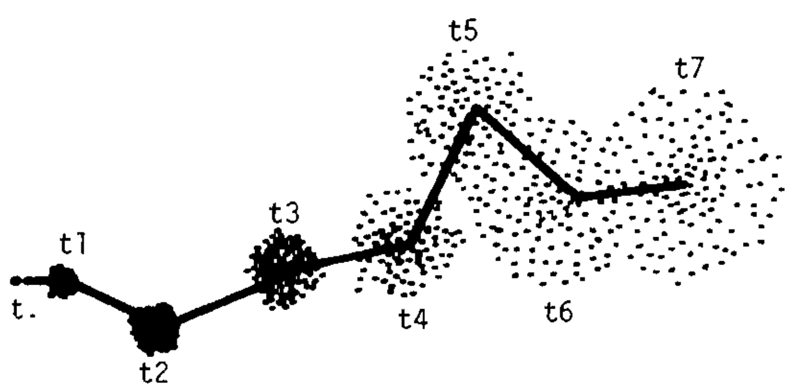
In an attempt to improve on some of the disadvantages of the plume models, the Gaussian puff models have been developed. The transformation of Equation 3 to the Lagrangian (moving) coordinate system is one which moves with the puff and retains time dependence, but the computations become extremely lengthy for multiple-source situation. The solution remains valid for light wind conditions unlike the plume models.

Refinements for elevated sources and receptors are also possible as in the case of the plume models. A similar decay term may also be incorporated. Line source formulas have been developed for the general case of highways at any angle to the mean wind. When the angles are small, the same formula applies but the line must be broken into shorter segments and contributions from each segment must be added.

These models follow the history of a polluted puff as it travels downwind and disperses in a Gaussian distribution (Figure 4.9). The trajectories of the air flow must be known and a puff moving along a trajectory must

FIGURE 4.9

GAUSSIAN PUFF IN A VARIABLE WIND FIELD



pass over the receptor in order to predict concentrations at a downwind receptor. Both the determination of the trajectory pattern and the number of puffs that must be followed requires the use of computers to obtain a fair representation of the concentrations over the study area.

As in the Gaussian plume formulation, topography is difficult to incorporate. Background contributions to the pollutant are allowed to vary in time and can thus be better incorporated. The primary disadvantages to this approach are the computational requirements of time and storage.

Available Manual Methodologies for Gaussian Dispersion Modeling

The modification and application of the basic Gaussian model for manual solution in a variety of situations is presented in [19,20,21]. For applications to any specific situations, it is suggested that the reader refer to these or other references on Gaussian dispersion modeling. Williamson [20] is recommended as an introduction to the analytical considerations of the Gaussian model. For point sources, the work by Turner [19] is recommended.

For line sources, a recent survey report [22] of highway models recommends among others the Highway Air Quality Impact Assessment Model of the California Department of Transportation.

The User Manuals [23] for the Highway Model covers six topics as follows:

1. Meteorology and its Influence on the Dispersion of Pollutants from Highway Line Sources

2. Motor Vehicle Emission Factors for Estimates of Highway Impact on Air Quality

3. Traffic Information Requirements for Estimates of Highway Impact on Air Quality

4. Mathematical Approach to Estimating Highway Impact on Air Quality

5. Analysis of Ambient Air Quality for Highway Environmental Projects

6. A Method for Analyzing and Reporting Highway Impact on Air Quality

The User Manuals are oriented for use by highway engineers in preparing the air quality elements of environmental impact statements for highway projects. The manuals provide an excellent introduction to the modeling of air pollutant dispersion from line sources. Manual solutions for many highway configurations and meteorological conditions are possible through the use of graphical solutions for the basic Gaussian diffusion equations.

Solutions for area source models based on dispersion principles are possible but are often very time consuming. Most solutions involve the use of digital computers. A simple but physically realistic model has been developed by Hanna [24] for estimating pollutant concentrations due to area sources. In this model, the surface concentration is directly proportional to the wind speed. The area source emissions for individual grid squares should be uniformly distributed within each grid and the source strength of adjacent grid squares should not differ too greatly.

4.2.3-2 The Air Pollution Potential Model

Another simple urban dispersion model has been developed by Miller and Holzworth [25]. The model calculates the average normalized concentration ($\overline{X}/\overline{Q}$) i.e., the concentration (X) averaged over a city and normalized for a uniform average area emission rate (Q) as a function of mixing height (H), wind speed ($\overline{u}$), and along-wind distance (S) across the city. The main assumptions of the model are:

1. Steady-state conditions prevail
2. Emissions occur at ground level and are uniform over the city
3. Pollutants are nonreactive
4. Lateral dispersion can be neglected
5. Vertical dispersion from each elemental source conforms to unstable conditions, and concentrations follow a Gaussian distribution out for a defined travel time that is a function of mixing height. Thereafter, a uniform vertical distribution of pollutant occurs as a result of further dispersion within the mixing layer.

The model treats the city as a continuous series of infinitely long cross-wind line sources with pollutants confined to the mixing layer. As indicated in assumption 5, the model requires two equations according to whether *none* or *some* of the pollutants emitted at ground level achieve a uniform vertical distribution within the mixing layer before being transported beyond the downwind edge of the city.

When <u>none</u> of the pollutants achieve a uniform vertical distribution, the equation may be written as

$$\overline{X}/\overline{Q} = 3.993(S/\overline{u})^{0.115} \text{ for } (\overline{S}/\overline{u}) \leq 0.471\ H^{1.130}$$

When <u>some</u> of the pollutants achieve a uniform vertical distribution, the average normalized concentration is

$$\overline{X}/\overline{Q} = 3.613\ H^{0.130} + \frac{S}{2HU} - \frac{0.088\overline{u}H^{1.260}}{S} \text{ for } (\overline{S}/\overline{u}) \geq H^{1.130}$$

For most cases the coefficient 0.088 is very small, and can be neglected [25].

This model was utilized to assess the mesoscale primary pollution potential for California [26]. Air pollution potential is a measure of the inability of atmospheric processes to adequately dilute and disperse pollutants. The pollution potential concept is valuable in relating changes in emissions to changes in air quality. An area of high air pollution potential will experience a relatively large degradation in air quality with increased emissions. Conversely, an area with low air pollution potential will experience a relatively small change in air quality for an identical change in emissions.

Air pollution potential is treated with statistical tools, in which the frequency of occurrence of meteorological events is of primary importance. For example, the pollution potential of a stable primary pollutant would be considered high in an area where light winds and strong, surface-based inversions occurred simultaneously and with great frequency. In assessing the air pollution potential for a particular area, emission factors are normalized or assumed to be constant. The model determines the spatial and temporal distribution of air pollution potential as a function of meteorological parameters only.

The meteorological parameters used to quantify the air pollution potential model are average wind speed and mixing height. These are determined from data on the wind and temperature structure of the lower layers of the atmosphere. Both of these meteorological variables can change rapidly in space and time. The pollution potential is an inverse function of the average wind speed and mixing height in this model. There are several ways to use wind and stability data to calculate pollution potential. Estimates of vertical atmospheric stability are made by following a procedure whereby stability criteria are divided into six classifications depending on the surface wind speed and the intensity of incoming sunlight [19,27]. From these classifications, pollution potentials are calculated using wind speed, mixing height, and normalized emission rates.

In the equations for the model, the values for mixing height (H) and mixing layer average wind ($\overline{u}$) are in the denominator. If either of these terms becomes very small, the value of $\overline{X}/\overline{Q}$ becomes very large and must be used with caution as a measure of urban pollution potential. The minimum values of morning mixing height (H) from the data are 45-50 meters [26]. With low mixing heights and wind speeds near zero, the term $\overline{X}/\overline{Q}$ becomes very large. For example:

| Mixing Height (meters) | Surface Wind (knots) | Boundary Layer Winds (meters/sec) | Urban Pollution Potential ($\overline{X}/\overline{Q}$) |
|---|---|---|---|
| 50 | 0 | 0.175 | 584 |
| 50 | 1 | 0.687 | 153 |
| 50 | 2 | 0.199 | 90 |

High values of $\overline{X}/\overline{Q}$ should be used cautiously when related to pollution potential. For all cases, the ratio $\overline{X}/\overline{Q}$ is calculated for a source size (i.e., city size) of 10,000 meters in the direction of the wind [26].

4.2.3-3 The Moving Box Model Approach

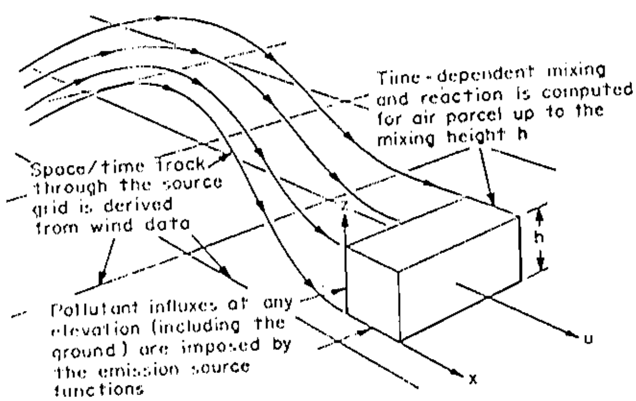
An alternative approach to air pollution modeling has been advanced by those investigators who have been concerned with the photochemistry of air pollution. In this case, the conservation of mass equation (Equation 1) is reduced to

$$\frac{\partial C_i}{\partial t} = R_i + S_i$$

A Lagrangian coordinate system is employed such that V = 0 while $K_x = K_y = 0$ and $K_z = \infty$. Or, in other words, a box is assumed to be carried by the winds with no lateral dispersion of pollutants allowed, while the pollutants emitted are presumed to mix instantaneously throughout the volume of the box. A later version of the moving cell model includes an analytical solution to accommodate horizontal dispersion [22]. The box may either extend from the ground up to the inversion base, or be represented by a column of boxes up to the inversion base (Figure 4.10). The simplifications made in this approach are clearly not representative of the actual atmospheric processes which affect the transport and dispersion of pollutants.

FIGURE 4.10

THE TRAJECTORY MODEL




SOURCE: (31)

In addition to its obvious misrepresentations, there are more subtle difficulties inherent in this moving-box approach. First, the technique by which the boxes are transported from one location to the next involves a wind trajectory analysis which is typically done by interpolation of wind measurements taken at ground level wind stations [29,30]. Generally, measurements of this type are not representative of the transport taking place throughout the vertical column. The proximity to buildings, the height of upwind buildings, and the stability of the atmosphere combine to modify the ground level measurements so that only estimates can be made of processes transpiring aloft. Thus, it must be anticipated that as the box is transported further and further downwind, the errors become larger and larger. This problem becomes acute with the complex wind patterns of California coastal air basins.

Second, the resulting computed concentrations are <u>instantaneous</u> values rather than hourly-averaged values. No attempt has been made thus far to justify the assumption that the instantaneous concentrations computed by a box model at a particular receptor point (i.e., at the site of a monitoring station) is representative of the hourly-averaged concentrations which are measured, and which also constitute the basis of the National Ambient Air Quality Standards. In particular, the technique employed by Eschenroeder and Martinez [29] for model validation purposes bears no relationship to the way air quality standards are defined. The time variation of pollutant concentrations in the box is computed at various points along its trajectory, and these computed values are compared not to actual monitoring data, but to values interpolated between monitoring stations nearest to the path of the box. In order for the box models to compute representative hourly-averaged concentrations at specified receptor points, trajectories would be needed for boxes arriving at each receptor point at, say, ten-minute intervals.

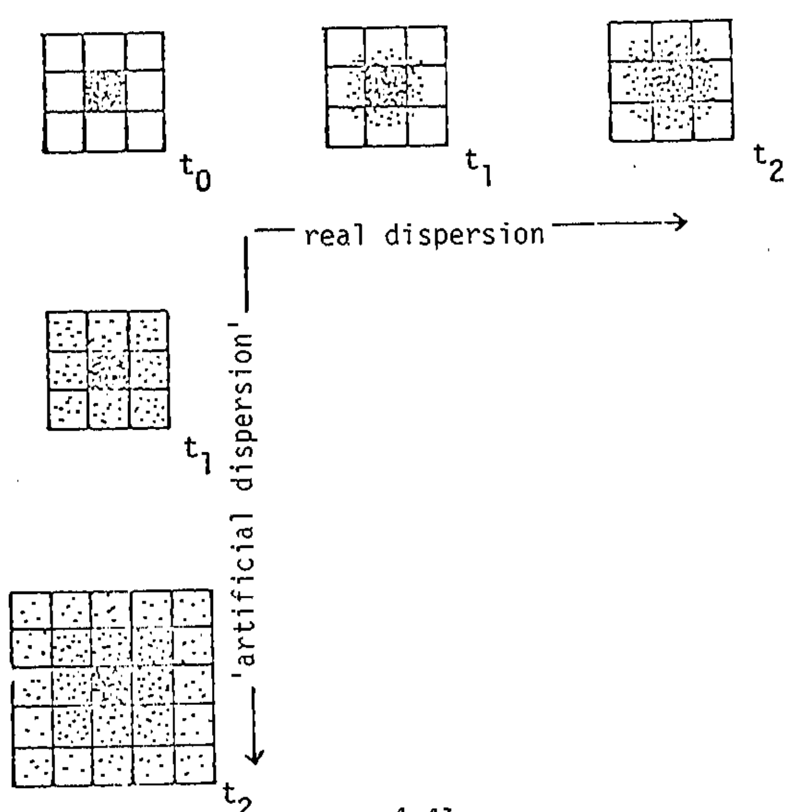
### 4.2.3-4 The Three Dimensional Grid Approach

The limitations of the Gaussian plume and moving box models, coupled with the need for more precise representations of air quality, have prompted a move toward the numerical solution of the conservation of mass equation on a fixed three-dimensional grid, including advection, dispersion and chemical reactions. Models which use this approach are quite complex and require much more data than are normally available for any given air quality control region. The level of <u>precision</u> (not necessarily accuracy) is correspondingly increased, however, such that more complex meteorological conditions may be accounted for and the model can in theory be applied to a greater variety of adverse situations occurring in the atmosphere over urban centers.

Unfortunately, many of the criticisms described for the box models may also apply to the grid models, particularly with respect to uncertainties in trajectories for air parcels. The disadvantage unique to the grid approach involves the phenomenon of numerical dispersion, also called artificial dispersion. In this case the finite difference solution of the conservation of mass equation introduces a machine-induced error into the analysis.

FIGURE 4.11

ARTIFICAL DISPERSION



Artificial dispersion is based on the assumption that pollutants are completely mixed and uniformly distributed in any given cell. For any time increment of a simulation, a certain amount of pollutant will be dispersed from each cell to adjacent cells. These pollutants are assumed to be spread evenly throughout the adjacent cells. In the next time increment, pollutants will be leaving these adjacent cells when in reality the pollutants have not traveled completely across the cells. Artificial and real dispersion are shown schematically in Figure 4.11.

### 4.2.4 Meteorological Sub-Models

#### 4.2.4-1 Wind Fields

Wind behavior is almost invariably separated into two parts for modeling. Relatively large scale motions are described as transporting the pollution from source to receptor while relatively small scale motions are described as dispersing and mixing the pollutant as it is transported.

The simplest models assume that the mean winds (large scale motions) are constant in time and space and unchanging in either speed or direction. This is the assumption utilized in the Gaussian plume model. The values of wind speed and direction can be based on observations from a single location or a combination of observations from several locations.

In more complicated and realistic models, winds can be simulated from point to point with both vertical and horizontal variations. In the vertical, wind speeds almost always increase with height. Some approaches allow for vertical speed variation by using specified functions - such as a "power low function" in which wind speed is proportional to altitude raised to an exponent, i.e., $\overline{u} \propto Z^n$. Wind direction changes with height are more difficult to specify and to fit into models. Only if the wind is measured or carefully worked out from dynamic theory can realistic direction changes with height be incorporated into models.

Realistic horizontal wind variability is relatively difficult to incorporate into models. The dominating principle is the conservation of mass, for both the pollutant and the air. Models include schemes of varying complexity to meet this requirement. A relatively simple method is to calculate two-dimensional horizontal motion from a wind stream function and assume no vertical motion. This type of flow does not permit convergence or divergence of mass.

The mass-consistent wind formulation [32] is a more complicated technique for defining a wind field. With this approach, ground level wind observations at discrete points in space are interpolated and then adjusted to satisfy the continuity equation of fluid flow.

In the case of incompressible flow, the equation may be written as:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

where u and v are the lateral components of the wind vector and w is the vertical component of the wind vector. The resulting wind field gives the speed and direction at all points within the grid, and is theoretically consistent. Significant differences occur between an interpolated wind field and an interpolated wind field adjusted to be consistent with the continuity equation of wind flow. The interpolated observed wind field is obtained from wind monitoring stations which are subject to local influences and give little information concerning upper level winds. The mass-consistent wind field is produced depending on the nature of the wind shear and inversion height assumption. Until mixing depth and upper level winds are monitored as regularly as present ground level winds, the validity of either wind field will remain in question.

The role of small scale motions and turbulent eddies in dispersing pollution is handled by the models in several ways.

The most common method used in the Gaussian formulation is based on the relationship between the spread of a pollutant cloud, the distance from the source, and the meteorological conditions which control turbulent eddy mixing. These relationships are developed from experimental observations of plumes. This, together with the assumption of a Gaussian or "normal" distribution and the conservation of pollutant mass allows an estimate of concentration at any point downwind from the source.

The dispersion equation uses eddy diffusivity coefficients or "K" theory to account for the role of small wind eddies. This assumes that there will be a movement of pollutant from a region of higher concentration to regions of lower concentrations and this flow is proportional to the eddy diffusivity and to the change of concentration per unit distance across the area. This method parallels solution techniques for molecular diffusion problems.

Both theories mentioned above can be applied to the same problem. The advantage of "K" theory is a much greater versatility, but it is limited by greater computing time requirements and a greater chance of computational errors.

#### 4.2.4-2 Mixing Depth

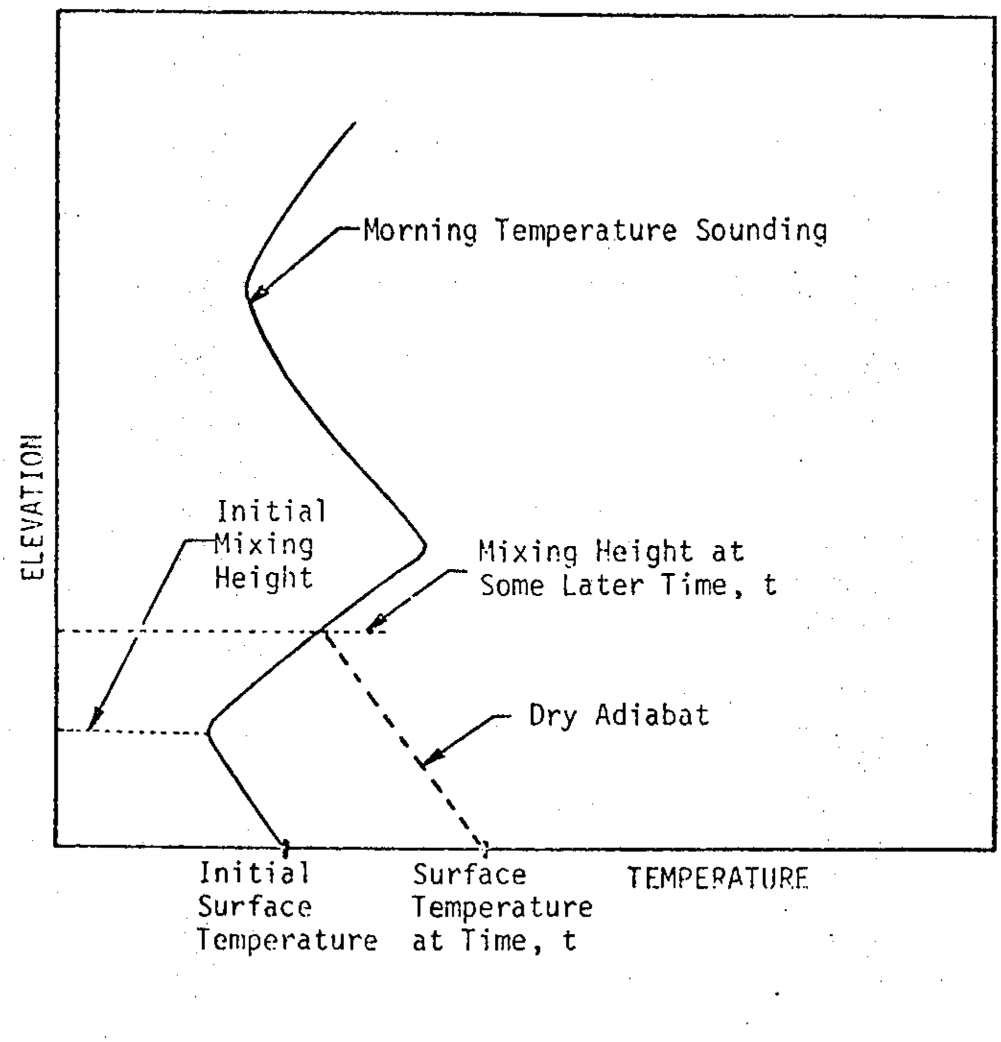
Two related techniques have been used to estimate the mixing depths (the height of the inversion base above the ground) over an urban area. The first technique was developed by Holzworth [33]. Here it is assumed that nighttime radiational cooling of the ground and heat loss from the air to the cool ground result in stable lapse rates at night; and that during the day, absorption of solar radiation by the ground and heating of the air results in unstable lapse rates and vertical motions (mixing) that ultimately produce a mixed dry adiabatic layer. Neglecting factors (e.g., advection, subsidence, etc.) that could change the vertical temperature profile after its time of observation, it is assumed that the mixing depth depends upon the vertical temperature structure and the surface temperature. This last assumption must be further conditioned by the fact that effects of vertical wind shear and mechanical turbulence in augmenting or diminishing vertical mixing have been neglected. In some cases, these factors may be important, but here only the effects of convection are considered. Since radiosonde observations are seldom made at the times of interest, the mixing depths are estimated by extending a dry adiabat from the maximum surface temperature to its intersection with the most recently observed temperature profile (Figure 4.12).

A second method [32] recognizes that the temperature profile observed at one location may not necessarily be assumed to apply in other locations, especially if the topography is complex. This method correlates the difference in mixing depths with the difference in surface temperatures recorded at a reference station with those at other locations in the study area. A set of curves is then prepared such that the mixing depth at the reference station may be used to predict the mixing depth at the other locations around the urban area on the basis of surface temperature measurements. Unfortunately, data were insufficient to properly define the correlation curves, and it remains to be seen whether such a technique can serve to adequately describe the substantial spatial and temporal variations characteristic of inversions, particularly those which occur over California coastal regions.

In addition to the effect which the mixing depth estimate has on the computed wind field, the significance of errors in mixing depth with regard to the impact on computed concentrations is also a function of the atmospheric stability within the mixing layer. If the mixed layer is highly unstable, then pollutants emitted at ground level will be mixed upward rapidly, and the mixing depth will be a direct determinant of computed ground level concentrations. If the mixing layer is relatively stable, the effect of the mixing depth at a given location will not be seen until the emitted pollutants are transported further downwind, since a longer time period would be required for the pollutants to mix upward and "sense" the presence of the inversion.

## FIGURE 4.12

## THE DETERMINATION OF MIXING HEIGHTS FROM SURFACE TEMPERATURE DATA




**SOURCE: (33)**

Perhaps the most critical aspect of estimating the mixing depth lies in the representation of an inversion base when it is at or near ground level. This particular condition is of utmost concern since it is often associated with severe air pollution episodes. Small fluctuations in the mixing depth under such conditions can lead to significant changes in ambient concentrations since the proportional change in the volume of air available for mixing may be quite large.

#### 4.2.4-3 Diffusivities

To date, there has been a single, standard approach to the estimation of diffusivity coefficients and/or standard deviations of the wind field. This approach was originally advanced by Pasquill [27] on the basis of plume measurements taken in areas of flat topography with no nearby bodies of water. Subsequent attempts at estimation of diffusivity coefficients have been geared toward improving the data or modifying the results in order to account for more complex terrain conditions, such as that posed by a city [34].

There have been few measurements of these important parameters which may be used directly in the various models. Hence, more often than not, the diffusivities become "free" parameters which are adjusted to produce the best fit of model results to observations during the validation phase of model development.

#### 4.2.4-4 Solar Radiation

The intensity of solar radiation is a critical factor in the photochemical processes leading to the formation of oxidant. Under uniform sky conditions the radiation intensity may be determined for an urban area. Problems occur when patchy or variable clouds are present, since the intensity may be drastically diminished in areas where direct sunlight is blocked. Reynolds, et al. [35] in their validation of the SAI Model noted that:

"In comparing the radiation profiles measured at the two measurement sites, Commerce and El Monte, for each of the six validation days, it is apparent that they are often not coincident. For example, on 29 September at noon the radiation intensity at El Monte was 30% lower than at Commerce. Consequently, the measures of photolysis rate, k1 and k7, differed by 30% between the sites. While we have adopted "averaged" curves based on measurements made at the two locations, it is clear that radiation intensity varies spatially as well as temporally, and that these variations can have a significant effect on the magnitudes of predicted concentrations. For example, if the steady-state approximation is valid, k1 is proportional to ozone concentration. A 30% error in k1, due to inaccuracies in estimation of the constant locally, will then result in approximately a 30% error in predicted ozone level."

### 4.2.5 Additional Considerations in Air Quality Modeling

#### 4.2.5-1 Boundary and Initial Conditions

To simulate a particular day of high air pollution potential, it is necessary to make some assumptions about conditions on the boundaries of the modeling region. Normally, there is little or no data concerning pollutant concentrations at the boundaries since they are chosen such that the entire urbanized area is contained within the model. Likewise, there is no monitoring data available (except in special cases) concerning the initial vertical profiles of pollutant concentrations.

The procedure that is followed almost universally is to assume that there is no gradient in concentration across any boundary, and that the initial profiles are uniform with height above ground level. The errors which are introduced into the modeling process due to such assumptions are difficult to assess, since conditions will vary from day to day. Unfortunately, one of the more controversial aspects of control strategy development centers on the question of pollutant transport from one air basin to another. In regions where such controversies exist, the ability to properly set the boundary conditions is critical to the success of the modeling effort.

4.2.5-2 Sub-Grid Scale Methodologies

In the case of three-dimensional grid models, there are important processes occurring on scales smaller than the grid can resolve. Strong point and line source emissions such as from power plant stacks and street "canyons," respectively, require special treatment in order to be properly considered in these models.

To date, three of the models currently available have incorporated sub-models which address sub-grid scale considerations. These are the Stanford Research Institute (SRI) APRAC-1A model for carbon monoxide, and the Systems Applications Incorporated (SAI) Urban Airshed Model and $S^3$ EXPLOR model for photochemical pollutants. The SRI model has a street canyon sub-model which describes, in a relatively simple fashion, the circulation pattern expected to occur over a street that is bounded on both sides by tall buildings. The SAI model for photochemical pollutants incorporates a more sophisticated street canyon sub-model as well as a simple point source treatment which allocates portions of a plume to the grid cells which the plume is expected to occupy. EXPLOR was specifically designed to predict pollutant concentrations in a milewide corridor transversed by a roadway. By dividing the airspace over the roadway into cells, an attempt is made to track the particles of pollutants from one cell to the next in a numerical integration of the conservation of mass equation in two dimensions.

Although it is important that such effects be addressed, it is not realistic to expect model results to be vastly improved as a result. When dealing with such complex phenomena on such a small scale as an individual street canyon, the variability of building heights, the presence of parked cars, the speed of the traffic on the street and various other factors become critical in the determination of pollutant concentrations. It is presently beyond the scope of any of the models developed to consider such effects, and thus it must be expected that results would not be consistently good.

#### 4.2.5-3 Chemical Reaction Sub-Models

In the case of photochemical oxidants, a special sub-model is required to describe the complex series of chemical reactions taking place in the atmosphere between the various pollutant species. Several reviews of atmospheric chemistry have appeared in recent years and a number of kinetic mechanisms for photochemical smog have been proposed [36,37,38]. Although the various mechanisms proposed produce reasonable agreement with smog chamber studies, it is clear that the nature of the multitude of reactions occurring in the atmosphere is not well understood. A polluted urban atmosphere typically contains upward of 100 hydrocarbon species, each of which may undergo any number of possible reactions with each other as well as with other atmospheric constituents. In addition, many of these species and their intermediate products are present in very low concentrations such that experimental studies are difficult if not impossible to conduct with available instrumentation. Thus, many of the rate constants used in chemical models have not been verified with actual experimental data.

For the purpose of an atmospheric simulation model, the kinetic mechanism must be as compact as possible to avoid excessive computing times in the numerical integration of the model. This requirement necessarily implies the use of a lumped-parameter approach, whereby a class of compounds or reactions are assumed to be described by a single compound or reaction with an "average" rate constant assigned. Additionally, the number of product molecules from a reaction may be assigned. The method by which such assignments are made involves the fitting of model results to smog chamber data.

Although this approach is reasonable under the circumstances, it is also fraught with uncertainty. Curves of pollutant concentrations vs. time may be produced with any desired shape if a sufficient number of free parameters are available for adjustment. Whether the kinetic mechanism thus developed is representative of what actually occurs is strictly a matter of conjecture, since the reactions that occur in a smog chamber are not necessarily similar to the reactions and other processes which occur in the ambient atmosphere (e.g., the formation of photochemical aerosol). These fundamental problems occur for any photochemical model, no matter how intricate its formulation.

Of the kinetic mechanisms published to date, the 15-step model of Hecht and Sienfeld [38] replicates smog chamber data rather well, in addition to being relatively compact. The fifteen steps are summarized in Table 4.2, where the symbol R denotes a generalized hydrocarbon radical; $\alpha$, $\beta$, and $\gamma$, are adjustable coefficients; and PAN denotes peroxyacyl nitrates.

The first three steps involving nitric oxide, nitrogen dioxide, ozone and sunlight ($h\nu$) describe the formation and destruction of ozone in the absence of organic gases. These steps are common to all of the kinetic mechanisms which have been proposed. The mechanisms diverge when it comes to describing how the presence of organic gases disrupts this equilibrium situation.

### 4.2.6 Statistical Models

#### 4.2.6-1 Appendix J Relationship

The Appendix J relationship for photochemical oxidants was developed by the U.S. Environmental Protection Agnecy for use in the development of state implementation plans for the achievement and maintenance of the National Ambient Air Quality Standards for oxidant.

The EPA relationship was derived by plotting the peak one hour oxidant measurements from four different cities vs. the 6-9 a.m. ambient non-methane hydrocarbon measurement for the same day. A curve was then

TABLE 4.2

The 15-Step Mechanism of Hecht and Seinfeld for Photochemical Oxidant

| | | |
|---|---|---|
| $NO_2 + h_\nu$ | $\xrightarrow{1}$ | $NO + O$ |
| $O + O_2 + M$ | $\xrightarrow{2}$ | $O_3 + M$ |
| $O_3 + NO$ | $\xrightarrow{3}$ | $NO_2 + O_2$ |
| $O_3 + NO_2$ | $\xrightarrow{4}$ | $NO_3 + O_2$ |
| $NO_3 + NO_2$ | $\xrightarrow[H_2O]{5}$ | $2HNO_3$ |
| $NO + NO_2$ | $\xrightarrow[H_2O]{6}$ | $2HNO_2$ |
| $HNO_2 + h_\nu$ | $\xrightarrow{7}$ | $OH + NO$ |
| $CO + OH$ | $\xrightarrow[O_2]{8}$ | $CO_2 + HO_2$ |
| $HO_2 + NO$ | $\xrightarrow{9}$ | $OH + NO_2$ |
| $HO_2 + NO_2$ | $\xrightarrow{10}$ | $HNO_2 + O_2$ |
| $HC + O$ | $\xrightarrow{11}$ | $\alpha RO_2$ |
| $HC + OH$ | $\xrightarrow{12}$ | $\beta RO_2$ |
| $HC + O_3$ | $\xrightarrow{13}$ | $\gamma RO_2$ |
| $RO_2 + NO$ | $\xrightarrow{14}$ | $NO_2 + \varepsilon OH$ |
| $RO_2 + NO_2$ | $\xrightarrow{15}$ | PAN |

| | |
|---|---|
| $h_\nu$ | represents energy from sunlight |
| M | a third body (like $N_2$) which acts as a catalyst |
| $O_2$ | molecular oxygen |
| O | atomic oxygen |
| $O_3$ | ozone |
| NO | nitric oxide |
| $NO_2$ | nitrogen dioxide |
| CO | carbon monoxide |
| $CO_2$ | carbon dioxide |
| OH | hydroxyl radical |
| $H_2O$ | water vapor |
| $HO_2$ | hydrogen dioxide |
| $RO_2$ | a generalized free radical where R represents any HC chain |
| HC | a hydrocarbon usually averaged |
| PAN | peroxyacl nitrates |
| $HNO_2$ | nitrous acid |
| $HNO_3$ | nitric acid |

$\alpha, \beta, \gamma$ and $\varepsilon$ adjustable coefficients

Source [38]

drawn as shown in Figure 4.13 such that all points plotted are below it, thus representing an upper limit to possible oxidant concentrations for a given level of morning hydrocarbon concentration. This curve may then be used to construct a second curve which relates peak oxidant to percent emission reduction required to meet the standard (Figure 4.14). The second curve is known as EPA's "Appendix J" rollback curve.

The basic procedure for deriving the Appendix J curve is as follows:

1. Select the peak oxidant concentration and determine the corresponding non-methane hydrocarbon concentration as defined by the envelope curve shown in Figure 4.13.

2. The percentage rollback requirement to attain the 0.08 ppm oxidant standard is defined as follows:

$$\text{rollback} = \frac{H_1 - H_0}{H_1}$$

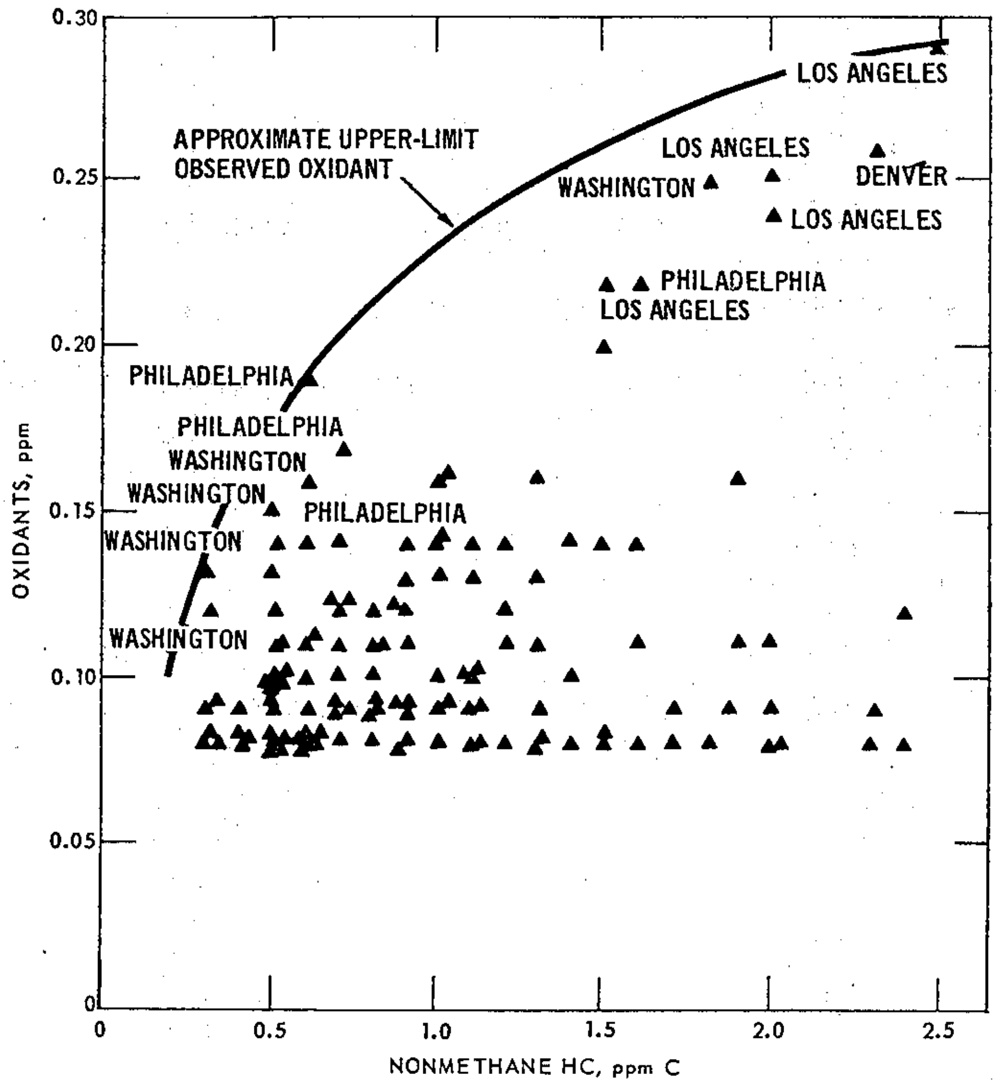
where $H_1$ = non-methane hydrocarbon concentration corresponding to the peak oxidant measurement

$H_0$ = 0.24 ppm non-methane hydrocarbon, as defined by the air qualtiy standard for hydrocarbons. This standard was selected as representing the hydrocarbon concentration corresponding to a peak oxidant level of 0.08 ppm. If the peak oxidant level is 0.23 ppm (corresponding to 1.0 ppm hydrocarbon), for example, then the percent emission reduction required is $\frac{1.0 - 0.24}{1.0} \times 100\% = 76\%$.

3. Repeat the computations for several values of peak oxidant to define the "rollback curve" shown in Figure 4.14.

FIGURE 4.13

MAXIMUM DAILY 1-HOUR- AVERAGE OXIDANTS
AS A FUNCTION OF 6-TO-9-A.M. AVERAGES
OF NON-METHANE HYDROCARBONS AT CAMP STATIONS

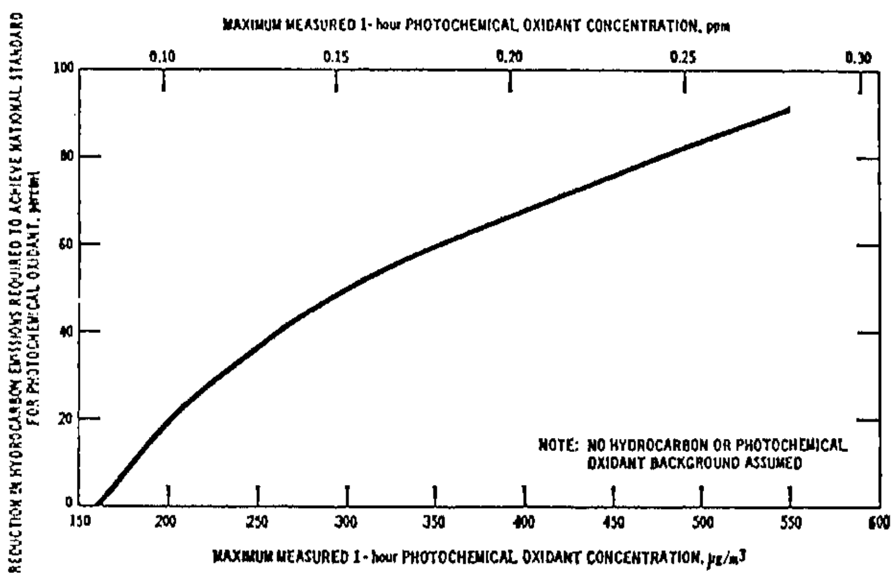



SOURCE: (39)

# FIGURE 4.14

# EPA'S APPENDIX J ROLLBACK MODEL FOR PHOTOCHEMICAL OXIDANTS

APPENDIX J




Required hydrocarbon emission control as a function of photochemical oxidant concentration. (Reference: Air Quality Criteria for Nitrogen Oxides, AP-84, Environmental Protection Agency, Washington, D.C., January 1971.)

SOURCE: (40)

There are several assumptions inherent in the development of this relationship, as summarized below:

1. The background concentration for oxidant is zero.

2. It is assumed that the 6-9 a.m. hydrocarbon measurement is directly proportional to total regional emissions.

3. It is assumed that the peak oxidant measured is representative of the peak oxidant which actually occurred in the region.

4. It is assumed that there is a consistent relationship between the peak oxidant measurement and the 6-9 a.m. hydrocarbon measurement (variable transport of pollutants is ignored).

5. It is assumed that the four cities for which data were used are representative of the nation as a whole.

In short, Appendix J ignores the space and time variable processes which are critical to determining the emissions/air quality relationship. Appendix J suffers from the problem that it must be assumed that the emission reductions will occur in the same proportion everywhere in the control region. Reliance on past data to define the relationship precludes a meaningful analysis of projected future emissions, which may be distributed quite differently from past emission patterns.

Finally, and perhaps most significant for control strategy development purposes, the Appendix J curve is undefined at peak oxidant concentrations above 0.28 ppm. For those air quality control regions with peak oxidant greater than 0.28 ppm, EPA has authorized the use of a linear rollback approach whereby oxidants are assumed to be directly proportional to hydrocarbon emissions (despite overwhelming evidence that the relationship is definitely non-linear). In this case, a 0.32 ppm peak oxidant measurement would imply that an emission reduction of

$\frac{(.32 - .08)}{.32} \times 100 = 75\%$ is necessary to achieve the oxidant standard. Note that this figure is <u>less</u> than the emission reduction required under Appendix J for a 0.23 ppm peak oxidant.

4.2.6-2 Proportional Model for Air Quality Estimates

The proportional model is a mesoscale approach to estimating air quality. This model assumes a linear relationship between the concentration of a pollutant in a study area and the emission rate of that pollutant in a study area. The proportional model as used in the State Implementation Plan [40] is applied to entire air basins. However, this model can be applied to a smaller study area when the transport of pollutants from other areas into the study area is not a significant consideration. The proportional relationship is represented by the following equation:

$$\text{Air Quality}_{\text{Future Year}} = B + (\text{Air Quality}_{\text{Base Year}} - B)\,\frac{\text{Emissions}_{\text{Future Year}}}{\text{Emissions}_{\text{Base Year}}}$$

Where B represents the background concentration due to natural phenomena. The air quality values used are the historical maximum concentrations of the pollutants in terms of the air quality standards.

This model requires representative air quality monitoring data for the study area and assumes that the meteorology for the study area will be similar for the base year and the future year.

The proportional model assumes that emissions are uniform throughout the study area and constant throughout the year of the emission inventory. In other words, temporal and spatial variations in emissions are not considered. Also, since there are many uncertainties concerning the relationship between the emissions of precursors of secondary pollutants and the resulting air quality, several simplifying conventions have been established to facilitate estimates of air quality. These assumptions are discussed below [41].

Convention 1. Air quality estimates for nitrogen dioxide ($NO_2$) are based on the emissions for all oxides of nitrogen.

This convention was established since there are few sources of $NO_2$, which is an unstable secondary pollutant. Nitric oxide (NO), which is generated mostly by high temperature combustion of fuels (automobiles and power plants), is the principal precursor of $NO_2$.

Convention 2. Air quality estimates for photochemical oxidants are based on the emissions of highly reactive organic gases.

The photochemical process that produces oxidants is a complex, multistep reaction that is not completely understood at this time. Air quality estimates based solely on the emission of highly reactive organic gases have a basic weakness in that the well-recognized role of oxides of nitrogen in the photochemical reaction is not considered.

The Appendix J relationship between non-methane hydrocarbons and photochemical oxidants [40] was developed for use in the preparation of control strategies for photochemical oxidant. Because of the scarcity of air quality monitoring data for non-methane hydrocarbons and questions as to the applicability of this relationship to the photochemical problem in California, the Air Resources Board staff did not use the Appendix J methodology. Instead, the ARB staff defined certain organic gas emissions as reactive and used a linear relationship between reactive organic gas emissions and oxidant concentrations.

Convention 3. Air quality estimates for particulate matter are adjusted to reflect the effect of natural or accidental phenomena.

The application of the proportional model to particulate matter is complicated by two additional factors. In some air basins, a significant portion of the atmospheric particulate matter is not directly emitted. Some is due to aerosols which are photochemically formed in the air and some is introduced into the air as a result of various

Table 4.3

ADJUSTMENT OF OBSERVED
PARTICULATE MATTER CONCENTRATIONS

| Air Basin | Adjustment | 1970 Annual Geom. Mean Observed Maximum | 1970 Annual Geom. Mean Adjusted Maximum |
|---|---|---|---|
| North Coast | 30 | 104 | 74 |
| San Francisco Bay Area | 30 | 74 | 44 |
| North Central Coast | 30 | 67 | 37 |
| South Central Coast | 30 | 72 | 42 |
| South Coast | 27 | 127 | 100 |
| San Diego | 30 | 87 | 57 |
| Northeast Plateau | -- | -- | -- |
| Sacramento Valley | 30 | 57 | 27 |
| San Joaquin Valley | 40 | 169 | 129 |
| Great Basin Valleys | -- | -- | -- |
| Southeast Desert | 40 | 128 | 88 |

From "The State of California Implementation Plan For Achieving and Maintaining the National Ambient Air Quality Standards," Air Resources Board, January 30, 1972. Appendix V.

natural phenomena such as wind-blown dust. The ambient levels of particulate matter reflect aerosols from each of these sources as well as directly emitted material.

A set of adjustments were assumed for the eleven air basins in the State in existence when the California Implementation Plan was developed. For the San Joaquin Valley and the Southeast Desert Air Basin a higher level was assumed because of the frequent occurrence of sandstorms and soil being carried by the wind. These adjustments are to be subtracted from the observed levels. Due to the variable nature of these natural phenomena, it is only possible to estimate them as annual geometric means. Table 4.3 presents the background estimates of pollutant used by the ARB [41].

A certain percentage of atmospheric particulate matter is generated by photochemical reaction. The following percentages are assumed for the South Coast Air Basin (SCAB) in 1970 [41]:

| Source | Relative Contributions of Particulate Matter In SCAB by Source |
|---|---|
| Directly emitted particulate matter | 40% |
| Photochemically generated particulate matter | 40% |
| Naturally occurring particulate matter | 20% |

For future year particulate matter air quality estimates, photochemically generated aerosols must be considered. These aerosols are estimated on the basis of the above assumptions and the following methodology:

$$\text{Photochemically-generated aerosols for SCAB in 19xx} = \frac{\text{Photochemically-generated Aerosols in SCAB for 1970}}{\text{Reactive Organic Gases in SCAB for 1970}} \; \text{Reactive Organic Gases in SCAB for 19xx}$$

Photochemically-generated aerosols for all other air basins were estimated in the State Implementation Plan using the following assumed relationship:

$$\text{Photochemically-generated aerosols in 19xx} = \frac{\text{Photochemically-generated Aerosols in SCAB for 1970}}{\text{Reactive Organic Gases in SCAB for 1970}} \; \text{Reactive Organic Gases for 19xx}$$

## Examples of Air Quality Estimates Using the Proportional Model

To estimate air quality using the proportional model, the following data are required:

1. Historical maximum concentration of pollutant of interest
2. Emission rate in study area of pollutant of interest based on emission inventory of the year in which historical maximum occurred
3. Naturally occurring background air quality
4. Estimated future year emission rate for study area

Similarly, to estimate the emissions allowable to achieve a certain air quality, the following data are required:

1. Historical maximum concentration of pollutant of interest
2. Emission rate for study area of pollutant of interest based on emission inventory of the year in which historical maximum occurred
3. Naturally occurring background air quality
4. Desired future year air quality

By substituting the four known values for either situation in the proportional relationship given above, the desired value is easily determined.

In Revision 4 to the State Implementation Plan [41], the following data for CO are given for the South Coast Air Basin:

| | For Carbon Monoxide For SCAB | | | |
|---|---|---|---|---|
| Year | 1970 | 1975 | 1977 | 1980 |
| Projected Controllable Emissions (tons/day) | 11548 | 6874 | 3033 | 2325 |
| Ambient Air Quality (8 hour average in ppm) | 41 | X | Y | Z |

To estimate future year air quality, the proportional model was used as follows: (NOTE: The CO background concentration was assumed to be zero.)

$$\frac{\text{1975 CO Air Quality}}{\text{1970 CO Air Qualtiy}} = \frac{\text{1975 CO Emissions}}{\text{1970 CO Emissions}}$$

$$\frac{\text{1975 CO Air Quality}}{\text{41 ppm for 8 hours}} = \frac{\text{6874 tons/day}}{\text{11548 tons/day}}$$

$$\text{1975 CO Air Quality} = \frac{(6874)}{(11548)}\ \text{41 ppm for 8 hours}$$

$$\text{1975 CO Air Quality} = \text{24.4 ppm for 8 hours} = X$$

Rounding off yields 1975 CO Air Quality = 24 ppm of CO for 8 hours. Referring to Table 2.1, this is above the standard of 9 ppm for 8 hours.

Similarly, for 1977 and 1980

$$\text{1977 CO Air Quality} = \text{1970 CO Air Quality}\ \frac{\text{1977 CO emissions}}{\text{1970 CO emissions}}$$

$$= (41)\ \frac{3033}{11549} = 10.8$$

Rounding values yields 1977 CO Air Quality = 11 ppm for 8 hours = Y. This value is still above the 8 hour standard for CO of 9 ppm.

$$\text{1980 CO Air Quality} = \text{1970 CO Air Quality}\ \frac{\text{1980 CO emissions}}{\text{1970 CO emissions}}$$

$$= (41)\ \frac{2325}{11548} = 8.25$$

Rounding, 1980 CO Air Quality = 8 ppm for 8 hours = Z. This estimate for CO air quality is below the 8 hour CO standard of 9 ppm.

In the original State Implementation Plan [41] the following data are given for the South Coast Air Basin:

| | Highly Reactive Organic Gases | | | | Particulates | | | |
|---|---|---|---|---|---|---|---|---|
| Year | 1970 | 1975 | 1977 | 1980 | 1970 | 1975 | 1977 | 1980 |
| Projected Emissions Directly Emitted (tons/day) | 1785 | 475 | 404 | 349 | 235 | 140 | 146 | 143 |
| Photochemically-generated Aerosols (tons/day) | | | | | 235 | X | Y | Z |

To estimate future year levels of photochemically-generated aerosols (PGA), the following relationship was used:

$$\text{Photochemically-generated aerosols for SCAB in 19xx} = \frac{\text{Photochemically-generated aerosols in SCAB in 1970}}{\text{Reactive Organic Gases in SCAB for 1970}} \text{ Reactive Organic Gases in SCAB for 19xx}$$

1975 Aerosols (PGA) $= \frac{235}{1785} 475$

1975 Aerosols (PGA) for 1977 and 1970 $=$ 63 tons/day = X

1977 Aerosols (PGA) $= \frac{235}{1785} 404$

1977 Aerosols (PGA) $=$ 53 tons/day = Y

1980 Aerosols (PGA) $= \frac{235}{1785} 349$

1980 Aerosols (PGA) $=$ 46 tons/day = Z

Total particulate emissions are the sum of directly emitted particulates and photochemically-generated aerosols. Naturally occuring particulate matter was not incorporated in this proportional model analysis.

For the South Coast Air Basin, in accordance with the original State Implementation Plan:

| Year | 1970 | 1975 | 1977 | 1980 |
|---|---|---|---|---|
| Directly Emitted Particulate Emissions (tons/day) | 235 | 140 | 146 | 143 |
| Photochemically-generated Aerosols (tons/day) | 235 | 63 | 53 | 46 |
| Projected Controllable Particulate Emissions (tons/day) | 470 | 203 | 199 | 189 |

### 4.2.6-3 Larsen's Model for Relating Air Quality Estimates with Different Averaging Times

The importance of developing air quality estimates based on averaging times identical to the air quality standards was discussed previously. The Larsen Model [42,43] provides a mathematical basis for relating air quality estimates to the ambient air quality standards when the averaging time for the two air quality values are different.

The Larsen Model incorporates the following assumptions of air quality monitoring data [44]:

1. Pollutant concentrations are log normally distributed for all averaging times, i.e., a graph of frequency on the vertical axis vs. the logarithm of the corresponding concentration values on the horizontal axis has a normal (bell-shaped) distribution.

2. Median concentrations are proportional to averaging times raised to an exponent, i.e., the data can be plotted as a straight line on logarithmic graph paper.

3. The arithmetic mean concentration is the same for all averaging times.

4. Maximum concentrations are approximately inversely proportional to the averaging times raised to an exponent.

5. For the longest averaging time calculated (usually one year) the arithmetic mean, geometric mean, maximum concentration and minimum concentration are all equal. This is possible since for the longest averaging time only one data point will be determined.

6. The arithmetic mean is proportional to regional emissions, i.e., pollutant burden.

The principal statistical parameters used in the model are:

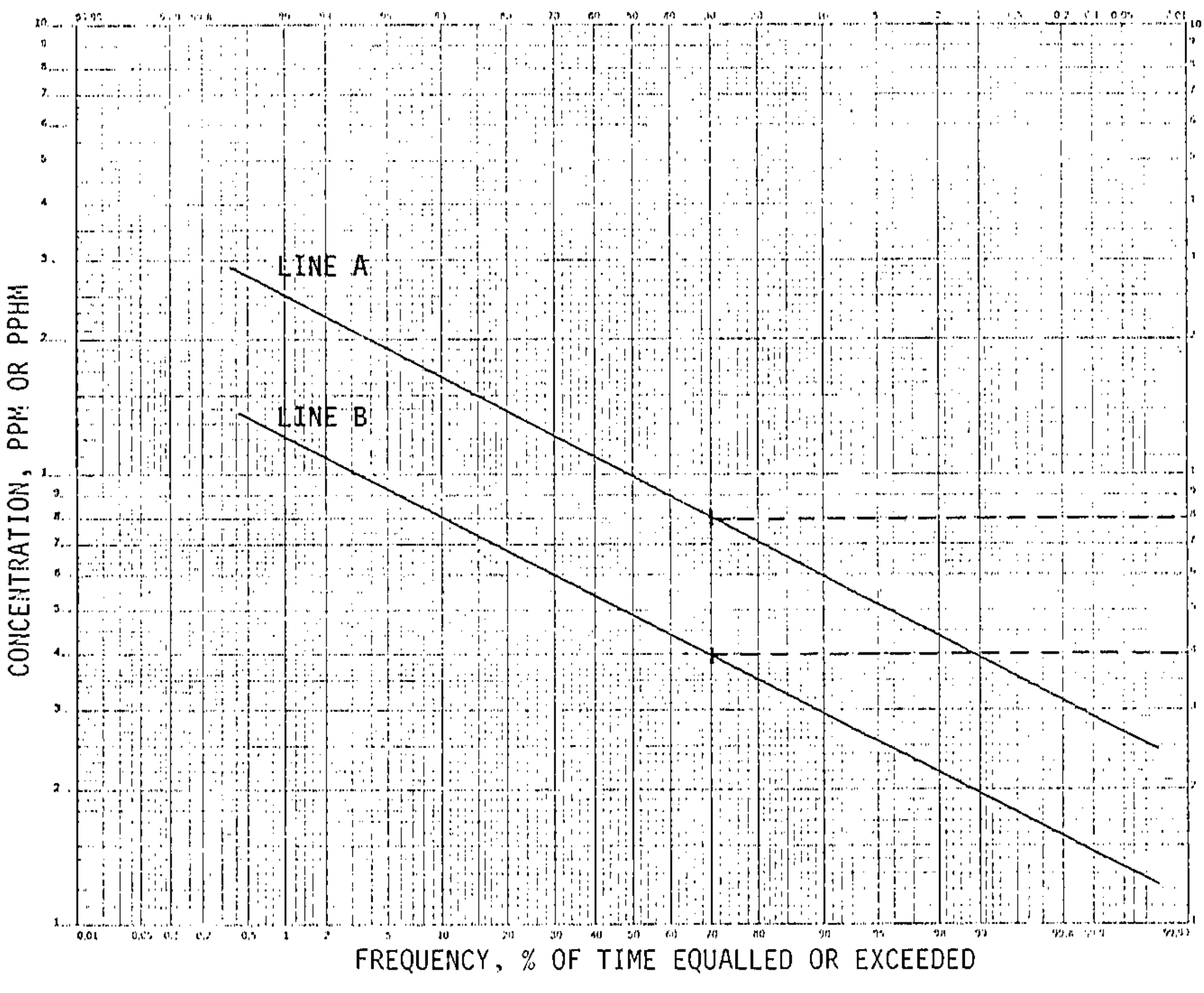
1. geometric mean or arithmetic mean
2. standard geometric deviation
3. maximum concentration expected once a year for a specified averaging time
4. frequency distribution of expected pollutant concentrations (this distribution is log-normal).

The Larsen model has been used to define expected maximum pollutant concentrations on the basis of historical data. In such an application, the data is plotted on special probability graph paper as shown in Figure 4.15 on a cumulative frequency basis (i.e., the percent of observations less than a given level). A best fit straight line (assuming the data is log-normally distributed) is then drawn through the upper portion of the data, and extended to the percentile representing a frequency of occurrence of once per year. The pollutant concentration corresponding to this point is interpreted to be the expected peak level for the data set. This technique has been useful in helping to determine whether a given peak concentration is reasonable or whether it is due to freak conditions of one kind or another.

A second application of the Larsen technique involves an implicit linear rollback assumption. A full year's worth of data is first plotted on log-probability paper. The arithmetic mean concentration, which is approximated by the 70 percentile value, is then interpreted to be proportional to emissions.

FIGURE 4.15

SAMPLE LARSEN ANALYSIS ON LOG-PROBABILITY PAPER




If the monitoring data follows Line A, then a 50% reduction in emissions would result in air quality defined by Line B. Given the arithmetic mean concentration of 8 ppm (70 percentile concentration), an emissions reduction of 50% inplies a new arithmetic mean concentration of 4 ppm.

The geometric standard deviation of the data is a measure of the variability of such variables as meteorological conditions, instrument changes, and emissions pattern changes. If the line defined by the data is raised or lowered proportionate to the expected change in regional emissions (using the 70 percentile point as a reference), the number of measurements above a given level (the air quality standard, for instance) expected to occur per year as a result of the emission change may be determined (Figure 4.15). Also the expected maximum value associated with the new level of emissions can be estimated.

Finally, a third application involves the coupling of the Larsen model with an annual average Gaussian plume model. Using annual average meteorological and emission input data, an appropriate Gaussian plume model would compute the annual mean concentration. By applying the Larsen analysis to historical monitoring data for a given region, the standard deviation of monitored pollutant concentrations may be determined and applied to the modeled average concentration to determine the projected peak concentration. This may be done for various averaging times, consistent with the averaging times used in the historical data. The Larsen analysis can be completed for each pollutant of interest using the historical air quality data for that pollutant.

As mentioned, the Larsen analysis assumes a log-normal distribution of concentration vs. averaging time. In practice, this analysis is applied only to the data for the higher recorded concentrations since other data may not approximate the log-normal distribution. This assumption of lognormality is not always valid [45] and its applicability to the air quality data for the study area should be evaluated before utilizing the Larsen technique. A further simplifying assumption is made, however, in order to bypass the need for a Gaussian plume analysis. This assumption is that the distribution of emissions does not change within the time frame of the analysis (i.e., that any emission increases or reductions occur proportionally throughout the region). Such an assumption may be valid over the short run, but is clearly not representative of what may be expected to occur over the long term.

The principal asset of the Larsen model is the minimization of requirements for sophisticated dispersion models without sacrificing the capability for estimating episode or worst-case situations.

Normally, the concentrations resulting from extreme meteorological conditions such as calm winds, recirculations, and fumigations cannot be handled very accurately by currently available dispersion modeling techniques. Moreover, any model which would be considered even reasonably suited to this task would be extremely sophisticated. Consequently, the air quality modeling for extreme meteorological conditions which are of greatest interest from an air quality standpoint has not met with a great deal of success [46].

When simpler methods are used to model air quality on a long-term averaged basis, the variance of air quality estimates are damped out. By using statistically based models such as the Larsen model, the variance lost by long-term averaging can be incorporated into the estimates.

The fundamental drawback to these statistical approaches, and indeed, to any approach which ignores the physical and chemical processes governing the accumulation and dispersion of air pollution is the fact that they are directly dependent on the conditions which prevailed at the time and place where their data base was gathered. Changes in emission patterns due to control programs or changes in urban form cannot be properly evaluated.

SECTION 4. - AIR QUALITY MONITORING AND AIR QUALITY MODELING

## REFERENCES


[1] California Air Resources Board, 1974 Annual Report, March 1975, p. 3.

[2] Nishikawa, N., Division of Technical Services, Air Resources Board. Memorandum and attachments to J. R. Kinosian, November 3, 1975.

[3] Morgan, George B. and Ozolinas, Guntes, "Air Quality Surveillance," Presented at 11th Conference Air Pollution and Industrial Hygiene Studies, University of California, Berkeley, California. March 30, 31 and April 1, 1970.

[4] Robert Maxwell, Air Quality Monitoring Section, California Air Resources Board, Personal Communication, July 10, 1975.

[5] California Air Resources Board, California Air Quality Data, Published Quarterly.

[6] __________, Ten Year Summary of California Air Quality Data, 1963-1972. January 1975.

[7] __________, "California Air Quality Data - Supplement for Environmental Impact Assessments," June 1974.

[8] U.S. Environmental Protection Agency, "Monitoring and Air Quality Trends Report, 1973," October 1974. EPA 450/1-74-007.

[9] Lewis Potter, Bay Area Air Pollution Control District, Personal Communication, May 30, 1975.

[10] Robert Maxwell, Air Quality Monitoring Section, California Air Resources Board, Personal Communication, May 29, 1975.

[11] Don Crowe, Air Quality Monitoring Section, California Air Resources Board, Personal Communication, June 3, 1975.

[12] Federal Register, Vol. 36, No. 158, August 14, 1971, pp 15488, 15491-2.

[13] Air Quality Engineering, Division of Technical Services, California Air Resources Board, Internal Report, July 9, 1975.

[14] Hildebrandt, Peter W., and Percy, Robert B., "Air Monitoring Criteria," Presented at 11th Methods Conference in Air Pollution and Industrial Hygiene Studies, University of California, Berkeley, California, March 30, 31 and April 1, 1970.

[15] Bemis, Gerald and Simeroth, Dean C., "Determination of a Factor for Standardizing Ambient Carbon Monoxide Data," Paper 75-45.3, Presented at 68th Annual Conference of Air Pollution Control Association, June 15-20, 1975, Boston, Massachusetts.

[16] Kinosian, John R., and Simeroth, Dean C., "The Distribution of Carbon Monoxide and Oxidant Concentrations in Urban Areas," Division of Technical Services, California Air Resources Board, October 1973.

[17] Millican, Roger C., "Decreased Atmospheric Ozone Near Roadways," Unpublished report, Department of Chemistry, University of California, Santa Barbara.

[18] Robert Maxwell, Air Quality Monitoring Section, California Air Resources Board, Personal Communication, August 27, 1975.

[19] Turner, D. Bruce, Workbook of Atmospheric Dispersion Estimates, U.S. Department of Health, Education, and Welfare, 1970, AP-26.

[20] Williamson, Samuel J., Fundamentals of Air Pollution, Addison-Wesley Co., Menlo Park, CA, 1973.

[21] Seinfeld, John H., Air Pollution: Physical and Chemical Fundamentals, McGraw-Hill, Inc., 1975.

[22] Badgley, Franklin I., Lamb, Donna V., and Rossano, August T., Jr., "A Critical Review of Mathematical Diffusion Modeling Techniques for Predicting Air Quality with Relation to Motor Vehicle Transportation," Departments of Atmospheric Sciences and Civil Engineering, University of Washington, Seattle, Wash., June 1973.

[23] Beaton, J. L., and A. J. Ranzieri, J. B. Skog, 1972: Air Quality Manual: Vol. I: Meteorology and Its Influence on the Dispersion of Pollutants from Highway Line Sources, Department of Transportation Report FHWA-RD-72-33.

Beaton, J. L., A. J. Ranzieri, J. B. Skog, 1972: Air Quality Manual: Vol. II: Motor Vehicle Emission Factors for Estimates of Highway Impact on Air Quality. Department of Transportation Report FHWA-RD-72-34.

Beaton, J. L., E. C. Shirley, J. B. Skog, 1972: Air Quality Manual: Vol. III: Traffic Information Requirements for Estimates of Highway Impact on Air Quality, Department of Transportation Report FHWA-RD-72-35.

Beaton, J. L., A. J. Ranzieri, E. C. Shirley, J. B. Skog, 1972: Air Quality Manual: Vol. IV: Mathematical Approach to Estimating Highway Impact on Air Quality, Department of Transportation Report FHWA-RD-72-36.

Beaton, J. L., A. J. Ranzieri, E. C. Shirley, J. B. Skog, 1972: Air Quality Manual: Vol. V: Appendix to Vol. IV, Department of Transportation Report FHWA-RD-72-37.

Beaton, J. L., A. J. Ranzieri, E. C. Shirley, J. B. Skog, 1972: Air Quality Manual: Vol. VI: Analysis of Ambient Air Quality for Highway Projects, Department of Transportation Report FHWA-RD-72-38.

Beaton, J. L., E. C. Shirley, J. B. Skog, 1972: Air Quality Manual: Vol. VII: A Method of Analyzing and Reporting Highway Impact on Air Quality, Department of Transportation Report FHWA-RD-72-39.

[24] Hanna, Steven R., "A Simple Method of Calculating Dispersion from Urban Area Sources," JAPCA, Vol. 21, No. 12, December 1971, pp. 774-7.

[25] Holzworth, George C., Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, Environmental Protection Agency, North Carolina, January 1972, AP-101.

[26] Unger, Charles D., Meteorological Parameters for Estimating the Potential for Air Pollution in California, California Air Resources Board, Land Use Planning Program, July 1974, NTIS No. PB 237 869/36A.

[27] Pasquill, F., The Estimation of the Dispersion of Windborne Material, Meteorology Magazine, Vol. 90;1063, pp. 33-49, 1961.

[28] Wada, Ronald Y., A Critical Assessment of the Role of Computer Models in Air Quality Planning and Decision Making, Environmental Science and Engineering, University of California, Los Angeles, 1975.

[29] Eschenroeder, A. Q., et al., "Evaluation of a Diffusion Model for Photochemical Smog Modeling," General Research Corporation, Final Report to EPA, October 1972.

[30] Wayne, L. G., et al., "Controlled Evaluation of the Reactive Environmental Simulation Model (REM)," Volume I, Final Report to EPA, Pacific Environmental Services, Inc., February 1973.

[31] Liu, Mei-Kao, and Seinfeld, John H., "On the Validity of Grid and Trajectory Models of Urban Air Pollution," Atmospheric Environment, Vol. 9, pp. 555-74, 1975.

[32] MacCracken, M. C., et al., "Development of a Multi-Box Air Pollution Model and Initial Verification for the San Francisco Bay Area," Lawrence Radiation Laboratory, University of California, August 1971.

[33] Holzworth, George C., "Estimates of Mean Maximum Mixing Depths in the Contiguous United States," Monthly Weather Review, n. 92, pp. 235-42, 1964.

[34] Bowne, N. E., "Diffusion Rates," Journal of the Air Pollution Control Association, Vol. 24, No. 9, pp. 832-835, September 1974.

[35] Reynolds, S. D., Lue, M. K., Hecht, T. A., Roth, P. M., and Seinfeld, J. H., (1973) Further Development and Validation of a Simulation Model for Estimating Ground Level Concentrations of Photochemical Pollutants, Vol. I, Systems Applications, Inc., San Rafael, California.

[36] Behar, J., "Simulation Model of Air Pollution Photochemistry," Project Clean Air, University of California, Volume 4, September 1970.

[37] Wayne, L. G., et al., "Modeling Photochemical Smog on a Computer for Decision-Making," Pacific Conference on Chemistry and Spectroscopy, 6th Western Regional Meeting, American Chemical Society, October 1970.

[38] Hecht, T. A., and J. H. Seinfeld, "Development and Validation of a Generalized Mechanism for Photochemical Smog," Environmental Science and Technology, Vol. 6, No. 1, January 1972.

[39] U.S. Environmental Protection Agency, "Air Quality Criteria for Nitrogen Oxides," AP-84, January 1971.

[40] Federal Register, Vol. 36, No. 158, August 14, 1971.

[41] California Air Resources Board, The State of California Implementation Plan for Achieving and Maintaining the National Ambient Air Quality Standards, February 1972.

California Air Resources Board, The State of California Implementation Plan for Achieving and Maintaining the National Ambient Air Quality Standards, Appendix V, February 1972.

California Air Resources Board, The State of California Implementation Plan for Achieving and Maintaining the National Ambient Air Quality Standards, Revision 3, June 1973.

California Air Resources Board, The State of California Implementation Plan for Achieving and Maintaining the National Ambient Air Quality Standards, Revision 4, December 1973.

California Air Resources Board, The State of California Implementation Plan for Achieving and Maintaining the National Ambient Air Quality Standards, Revision 5, June 1974.

[42] Larsen, Ralph I., "A New Mathematical Model of Air Pollutant Concentration Averaging Time and Frequency," JAPCA, Vol. 19, pp. 24-30, January 1969.

[43] Larsen, Ralph I., "A Mathematical Model for Relating Air Quality Measurements to Air Quality Standards," U.S. Environmental Protection Agency, November 1971, AP-89.

[44] Ranzieri, Andrew J., and Bemis, Gerald R., et al., Applications of Statistics in Analyzing Aerometric Data for Transportation Systems, California Department of Transportation Research Report, CA-DOT-TL-7082-9-74-38, October 1974.

[45] McGuire, Terry and Noll, Kenneth E., "Relationship Between Concentrations of Atmospheric Pollutants and Averaging Time," Atmospheric Science, Vol. 5, pp. 291-8, 1971.

[46] Thullier, Richard H., "A Regional Air Pollution Modeling System for Practical Application in Land Use Planning Studies," Technical Services Division, Bay Area Air Pollution Control District, May 1973.